4.0 ENVIRONMENTAL IMPACT ANALYSIS

This chapter addresses the potential impacts of the alternatives on a number of environmental factors. The effects of the alternatives regarding soils, geology and topography; hazardous materials contamination; air quality; noise and vibration, ecology and habitat; water quality and floodplains; energy and environmental justice are discussed in the following sections.

Graphics for Chapter 4.0 are included together at the end of the chapter.

4.1 SOILS, GEOLOGY AND TOPOGRAPHY

This section describes the existing soil characteristics, geology and topography in the vicinity of the proposed project.

4.1.1 Soils

The proposed project area lies within eight soil units. Soil data were obtained from digital soil surveys of Hennepin County and Ramsey County distributed by the Twin Cities Metropolitan Council. Digital soil data for Ramsey County were gathered from the Soil Survey of Washington-Ramsey Counties, April 1980 and Natural Resource Conservation Service (NRCS) Mylar Maps of the Washington-Ramsey Counties' Soil Surveys. Digital soil data for Hennepin County were gathered from the April 1974 Soil Survey of Hennepin County, Soil Conservation Service (now NRCS) soil maps produced for eastern Hennepin County in 1983, and NRCS Mylar Maps of the Hennepin County Soil Survey. Figure 4.1-1: General Soil Classification, depicts the location of the soil units determined for the proposed project. Soil descriptions were gathered from the soil survey of Washington and Ramsey Counties, April 1980 and the April 1974 soil survey of Hennepin County. These eight soils units are described below:

Antigo silt loam
This soil is well drained and hilly with slopes typically ranging between 12 percent and 18 percent. Typically the surface area is very dark grayish brown silt loam about 8-inches thick. The subsurface layer is grayish brown silt loam about 4-inches thick. The subsoil is dark yellowish brown silt loam about 12-inches thick and the underlying material is brown coarse sand and gravel.

Dorerton-Rock outcrop complex
This soil complex is well-drained and very steep (25 to 65 percent slopes). The surface layer of Dorerton soil is typically very dark gray sandy loam about 4-inches thick. The subsurface is dark brown fine sandy loam about 6-inches thick. The subsoil is about 12-inches thick and consists of dark brown gravelly clay loam in the upper part and dark brown flaggy clay loam in the lower part. The underlying material is pale brown flaggy loamy sand. Limestone bedrock underlies the soil between 45 and 70-inches below ground surface (bgs). Typically the rock outcrop consists of limestone bedrock 2 to 4-feet high and 10 to 50-feet long.

Lindstrom silt loam
This soil is well drained and very gently sloping (2 to 4 percent slopes). The surface soil is very dark gray silt loam about 37-inches thick. The subsoil is dark yellowish brown and yellowish brown silt loam about 21-inches thick. The underlying material is yellowish brown silt loam and in some areas has grayish brown mottles.

Udorthents, wet substratum

This soil has been placed as fill for buildings and roads. This fill material soil has been placed on poorly drained mineral and organic soil. Thickness of the fill material is generally more than 2-feet and is composed of organic and inorganic waste from human activity and sandy, gravelly, loamy and silty soil material. The fill may contain trash, demolition debris, industrial waste and concrete.

Urban land-Chetek complex

This soil has been predominantly developed for residential and commercial use. The somewhat excessively drained Chetek soils consist of undulating to hilly (3 to 15 percent slope) on outwash plains. In undisturbed areas, the surface soil is brown sandy loam and approximately 6-inches thick. The subsoil is reddish brown sandy loam approximately 12-inches thick. Underlying material is brown gravelly sand. In some areas, the soils have been removed and underlying material is exposed. Other areas are covered with varying depths of fill.

Urban land complex

This soil area is covered with buildings, asphalt, and concrete pavement. The Urban land complex area is predominantly level to gently sloping. Soils in these areas have not been identified as they have been altered by construction or are covered with factories, warehouses, shopping centers, railroad yards, and parking lots.

Urban land-Waukegan complex

This soil has predominantly been developed for residential and commercial use. The level to very gently sloping soil complex (0 to 3 percent slope) mainly covers outwash slopes and consists of well-drained Waukegan soils. In undisturbed areas, the surface soil is approximately 10-inches thick and very dark brown silt loam. The subsoil is about 21-inches thick, dark yellowish brown silt loam to coarse sand. Underlying material is coarse sand and fine gravel. In some areas the soils have been removed and underlying material is exposed. Other areas are covered with varying depths of fill.

Urban land-Zimmerman complex

This soil has predominantly been developed for commercial and residential use. The excessively drained Zimmerman soils are very gently to moderately sloping (1 to 8 percent slopes) on outwash plains. In undisturbed areas, the surface soil is dark grayish brown loamy fine sand approximately 15-inches thick. The subsoil and underlying material is light gray to pale brown fine sand. In some areas, the soils have been removed and underlying material is exposed. Other areas are covered with varying depths of fill.

The following Table 4.1-1: Detailed Soil Classifications and Limitations for Site Development, indicates the degree and kind of limitations that affect shallow excavations, small buildings, roads and streets, and lawns and landscaping. This information was obtained from the Soil Survey of Washington-Ramsey Counties, April 1980 by the Soil Conservation Service and the Soil Survey of Hennepin County, April 1974 by the Soil Conservation Service.

Table 4.1-1: Detailed Soil Classifications and Limitations for Site Development

Detailed Soil Map Unit	Hydric Soil	Limitations for Site Development						
		Shallow Excavations	Small Buildings	Roads & Streets	Lawns and Land-scaping	Potential Frost Action	Risk of Corrosion	
							Uncoated Steel	Concrete
Antigo silt loam, 12-18% slope	No	Severe: cutbanks cave, slope	Severe: slope.	Severe: slope, low strength	Severe: slope	Moderate	Moderate	High
Dorerton-Rock outcrop complex, 25-65% slope	No	Severe: slope	Severe: slope	Severe: slope	Severe: slope	Low	Low	Moderate
Lindstrom silt loam, 2-4% slope	No	Slight	Slight	Severe: frost action	Slight	High	Moderate	Moderate
Udorthents, wet substratum	No	Not Rated	Not Rated	Not Rated	Not Rated	-	-	-
Urban land Chetek complex, 3-15% slope	No	Severe: Cutbanks cave	Severe: slope	Moderate : slope	Moderate: slope	Low	Moderate	High
Urban land complex	-	Not Rated	Not Rated	Not Rated	Not Rated	-	-	-
Urban land Waukegan complex, 0-3% slope	No	Severe: Cutbanks cave	Slight	Slight	Slight	Low	Low	Moderate
Urban land Zimmerman complex,1-3% slope	No	Severe: Cutbanks cave	Moderate: slope	Slight	Moderate: too sandy	Low	Low	High

Notes:

Not Rated: Soils in these areas have been greatly altered by construction and determination of engineering capabilities is not feasible without actual soil boring information.

Slight: Soil properties and features are favorable for the indicated use and limitations are minor and easily overcome.

Moderate: Soil properties and features are not favorable for the indicated use and special planning, design or maintenance is required to minimize or overcome the limitations.

Severe: Soil properties and features are so unfavorable or difficult to overcome that special design, significant increases in construction costs and possibly increased maintenance is required.

Potential Frost Action

Potential frost action is the likelihood of upward or lateral expansion of soil caused by the formation of segregated ice lenses and the collapse of soil and loss of strength upon thawing. Potential frost action ratings (low, moderate, high) in Table 4.1-1 are based on the soils texture, density, permeability, organic matter content, and the depth to water table in each soil type as described in the following table. The ratings are established assuming that the soil is not insulated by vegetation or snow, and is not artificially drained.

Soil Moisture Regime	Low	Moderate	High
Aquic	Cindery, Fragmental	Sandy, Sandy-skeletal	Coarse-loam, fine-loamy, Coarse-silt, fine-silty, Clayey, Organic soil materials, Ashy, Medial, Hydrous
Udic, Xeric Ustic (when irrigated) Aridic (when irrigated)	Fragmental, Cindery, Sandy	Coarse-loamy, Fine-loamy, Clayey, Ashy, Hydrous, Medial	Coarse-silt, Fine-silty, Ashy, Medial, Hydrous
Ustic, Aridic	Fragmental, Sandy, Clayey, Cindery, Ashy, Medial	Coarse-loamy, Fine Loamy, Coarse-silty, Fine-silty, Hydrous	

Low: Soils are rarely susceptible to the formation of ice lenses. Soils are typically well-drained, very gravelly, or very sandy soils.

Moderate: Soils are susceptible to the formation of ice lenses, which results in frost heave and subsequent loss of soil strength. Soils are somewhat poorly to well drained, very fine to medium-well graded.

High: Soils are highly susceptible to the formation of ice lenses, which results in frost heave and subsequent loss of soil strength. Generally poorly drained, silty and highly structured clayey soil having a high water table.

Risk of Corrosion

Risk of corrosion pertains to potential soil-induced electrochemical or chemical action that dissolves or weakens uncoated steel or concrete. Risk of corrosion ratings (low, moderate, and high) in Table 4.1-1are based on various factors of soil chemistry as described in the following table.

Uncoated Steel

Corrosion of uncoated steel is caused by the potential soil-induced electrochemical or chemical action that converts iron into its ions, thereby dissolving or weakening uncoated steel. The risk of corrosion for uncoated steel is based on the soil drainage class, total acidity, and content of soluble salts as shown in the following table:

Property	Low	Moderate	High
Drainage class and texture	Excessively drained, coarse, or well drained, coarse to medium; or moderately well drained, coarse; or somewhat poorly drained, coarse.	Well drained, moderately fine; or moderately well drained, medium; or somewhat poorly drained, moderately coarse; or very poorly drained with stable high water table.	Well drained, fine or stratified; moderately drained, fine and moderately fine or stratified; somewhat poorly drained, medium to fine or stratified; poorly drained with fluctuating water table
Total Acidity (cmol/100g)	<8	8-12	>12
Resistivity at saturation (ohm/cm)	>5,000	2,000-5,000	<2,000
Conductivity of saturated extract (mmhos/cm^{-1})	<0.3	0.3-0.8	>0.8

Concrete

Corrosion of concrete is the susceptibility of concrete to corrosion when in contact with the soil. The risk of corrosion for concrete is based on soil texture, acidity, and amount of sodium or magnesium sulfates, and the amount of sodium chloride as shown in the following table:

Soil Property	Low	Moderate	High
Texture and Reaction	Sand and organic soil with pH >6.5; or medium and fine soil with pH >6.0	Sandy and organic soil with pH 5.5-6.5; or medium and fine soil with pH 5.0 to 6.0	Sandy and organic soil with pH <5.5; or medium and fine soil with pH <5.0
Na and/or Mg sulfate parts per million (ppm)	<1,000	1,000 to 7,000	>7,000
NaCl (ppm)	<2,000	2,000 to 10,000	>10,000

4.1.2 Surficial Geology

The surficial sediments of Hennepin and Ramsey Counties were deposited primarily by glacial ice and meltwater during the last glaciation (Wisconsinan Stage). Sediments along the major portion of the proposed project can be attributed to the advancement and retreat of the Superior lobe and Grantsburg sublobe of the Des Moines lobe, and meltwater from these lobes. The St. Paul Sand Flats, a broad sandy outwash plain, dominates this region. As the outwash plain was being deposited, the Glacial River Warren was deepening and sediments ranging from gravel to sand to some silt and clay were deposited along the terraces of the river.

Surface geology along portions of the proposed project located in Hennepin County is composed of middle terrace deposits, upper terrace deposits, sandy floodplain alluvium, and outwash. Data were gathered from the Minnesota Geological survey, *Geologic Atlas of Ramsey County, Minnesota* (*1992*).

- Middle and upper terrace deposits consist of sand, gravelly sand, and loamy sand, overlain by thin deposits of silt, loam, or organic sediment.
- Sandy floodplain alluvium consists of loamy sand, sand, and gravelly sand interbedded with and overlain by thin beds of finer sediment and organic matter.
- Outwash consists of sand, loamy sand, and gravel, overlain by loess less than 4-feet thick.

Surface geology along portions of the proposed project located in Ramsey County is composed of buried coarse meltwater stream sediment, meltwater stream sediment, till with stream-modified surface, glacial river stream sediment and stream sediment. Data were gathered from the Minnesota Geological survey, *Geologic Atlas of Hennepin County*, *Minnesota* (1989).

- Buried, coarse meltwater stream sediment buried by up to 40-feet of Grantsburg till. Grantsburg till consists of gray, loam-textured till, ranging from loamy sand to clay and commonly banded with reddish-brown Superior lobe till or sand, and thick yellow-brown or gray bands with thin red stringers near the land surface.
- Meltwater stream sediment consists of medium to coarse sand with pebbles. The sand is predominantly quartz with Cretaceous shale, limestone, and rare lignite grains.
- Till with stream-modified surface consists of gray, loam-textured till, ranging from loamy sand to clay and commonly banded with reddish-brown Superior lobe till or sand, and thick yellow-brown or gray bands with thin red stringers near the land surface. The till topography has been modified by running water and is covered in some places with thin, discontinuous sand and gravel.
- Stream sediment of Glacial River Warren consists of sand and gravel with some fine sediment (silt and clay).
- Stream sediment consists of sand and gravel with areas of fine sediment and organic material.

4.1.3 Bedrock Geology

The uppermost bedrock along the proposed project consists (from youngest to oldest) of Decorah Shale (shale), Platteville and Glenwood Formations (dolostone and limestone), St. Peter Sandstone (sandstone), and Prairie du Chien Group (dolostone). Bedrock geology data were gathered from the Minnesota Geological survey, *Geologic Atlas of Hennepin County, Minnesota* (1989) and the Minnesota Geological survey, *Geologic Atlas of Ramsey County, Minnesota* (1992).

- Decorah Shale consists of green calcareous shale with thin limestone interbeds.
- The Platteville and Glenwood Formations consist of fine-grained dolostone and limestone of the Platteville Formation underlain by thin, green, sandy shale (3 to 5.5-feet thick) of the Glenwood Formation.
- St. Peter Sandstone consists of fine to medium-grained quartz sandstone, massive to thick bedded, underlain by multicolored beds of mudstone, siltstone, and shale with interbeds of very coarse sandstone.
- The Prairie du Chien Group consists of sandy or oolitic, thin-bedded dolostone with thin beds of sandstone, chert, and intraclastic dolostone underlain by massive or thick-bedded dolostone. The lower part of the Prairie du Chien dolostone is not oolitic or sandy with the exception of a thin, sandy transitional zone at the base. The upper part of the Prairie du Chien dolostone may contain karst solution cavities, particularly where the overlying St. Peter Sandstone has been removed by erosion.

4.1.4 Topography

Land surface in the area of the proposed project ranges in elevation from less than 700-feet on the west end to 925-feet on the east end based on National Geodetic Vertical Datum (NGVD) of 1929. Topographic data were created utilizing the United States Geological Survey (USGS) 7.5-minute quadrangles, Digital Elevation model. Figure 4.1-2: USGS Elevation Contours, depicts the general topography in the vicinity of the proposed project. Topography is fairly rolling. The high point is located between the proposed Snelling Avenue Station and the proposed Lexington Parkway Station and the low point is near the Mississippi River, southeast of downtown St. Paul.

The west end elevation of the proposed project near the proposed Minneapolis Multimodal Station is approximately 830-feet. As the proposed project alignments proceed east through downtown Minneapolis, the elevation increases to approximately 850-feet, then gently slopes toward the west bank of the Mississippi River, where the elevation abruptly drops to approximately 725-feet (the approximate elevation of the river). On the east bank of the Mississippi River, the elevation abruptly increases to 810-feet then climbs gradually to 830-feet as the proposed project alignment proceeds east to the proposed Stadium Village Station. From the proposed Stadium Village Station to the proposed Westgate Station, elevation gains 60 to 70-feet. East of the proposed Westgate Station the topography is relatively flat and reaches 925-feet between the proposed Snelling Avenue Station and the proposed Lexington Parkway Station (the high point of the proposed project alternatives) then decreases to 890-feet at the proposed Lexington Parkway Station. From the proposed Lexington Parkway Station to the proposed Dale Street Station, topography is relatively flat around 890-feet. From the proposed Dale Street Station to the proposed Rice Street Station, elevation drops steadily to 865-feet. From the proposed Rice Street Station to the proposed Union Depot Station the elevation steadily decreases to 730-feet. As the Busway/Bus Rapid Transit (BRT) Alternative continues southeast the elevation drops to 700-feet on the north bank of the Mississippi River and 690-feet on the south bank of the river. At the end of the BRT Alternative the elevation increases to 710-feet.

4.1.5 Potential Environmental Impacts

BASELINE ALTERNATIVE

No significant impacts to the proposed project area soils or geology are anticipated in association with the Baseline Alternative because it utilizes the existing transportation network and only involves minor traffic engineering work rather than large roadway capacity expansions.

The majority of small-scale improvements included in the Baseline Alternative have already been completed. Only the rebuilding of a former transit bus garage near the intersection of Snelling Avenue and University Avenue, and the construction of a noise wall near the interchange of Interstate 94 (I-94) and Victoria Street remain to be completed. Based on its small scale the noise wall is not expected to impact area soils or geology. The rebuilding of the former garage is not expected to impact area soils or geology because any impacts were already made when the former garage was constructed.

UNIVERSITY AVENUE LIGHT RAIL TRANSIT (LRT) ALTERNATIVE

Soils of the Udorthent, wet substratum are present between Fifth Avenue North and Third Avenue North in downtown Minneapolis. They are also present between the proposed Raymond Avenue Station and the Fairview Avenue Station, and between the Dale Street Station and the Rice Street Station just north of the proposed project. These soils may pose development limitations due to wetness. They may also contain fill material including trash, demolition debris, industrial waste and concrete.

UNIVERSITY AVENUE BUSWAY/BRT ALTERNATIVE

Soils of the Udorthent, wet substratum are present along Third Avenue North in downtown Minneapolis, between the proposed Raymond Avenue Station and the Fairview Avenue Station, between Dale Street Station and Rice Street Station just north of proposed project, and just south of proposed project and Filmore Avenue East in St. Paul. The Busway/BRT would be operating in mixed traffic for much of the alignment with construction typically including signage and fare vending equipment. Soils of the Udorthent, wet substratum are not present in areas where there is construction with the exception of the reconstruction of a railroad between the Raymond Avenue Station and the Fairview Avenue Station.

4.1.6 Mitigation Measures

Special care concerning bank stabilization should be exercised in the vicinity of the Mississippi River. Erosion control measures including ground coverage and tree conservation should also be utilized throughout the proposed project.

New construction often involves precautionary exploration and at times requires the grouting of underground cavities. A more detailed analysis will be conducted for sites determined to be impacted by the proposed project. New construction in this area should be preceded by additional testing using ground-penetrating radar (GPR) or equivalent methods, to assure potential hazards are identified and proper structural mitigation measures are taken.

All project-related construction activity would adhere to appropriate standards and applicable permitting requirements of the Minnesota Pollution Control Agency (MPCA), Minnesota Department of Transportation (Mn/DOT), Hennepin County, and Ramsey County.

4.2 HAZARDOUS MATERIALS CONTAMINATION

The purpose of this section is to evaluate the likelihood of soil and/or groundwater contamination present on or in the immediate vicinity of the proposed project. This section assumes the Hiawatha LRT is in place prior to the implementation of the proposed project and appropriate remediation has occurred. Therefore this section only evaluates the portion of the proposed project east of the Downtown East/Metrodome Station.

SITE IDENTIFICATION

There is no single comprehensive source of information available that identifies known or potential sources of environmental contamination along the alternatives of the proposed project. Therefore, to identify and evaluate sites containing hazardous materials, petroleum products, or other sources of potential contamination in these areas; a government database search was conducted. This screening tool identifies locations of sites with known or potential environmental liabilities based on information contained in various federal and state government databases. The following databases were searched 1000-feet on either side of the proposed project alternatives:

- National Priority List (NPL)
- Resource Conservation and Recovery Act (RCRA) Corrective Actions (CORRACTS)
- Treatment, Storage, and Disposal (TSD) CORRACTS
- State Equivalent Priority List (SPL)
- RCRA permitted TSD facilities
- State equivalent CERCLIS List (SCL)
- Comprehensive Environmental Response, Compensation and Liability Information System/No Further Remedial Action Planned (CERCLIS/NFRAP)
- Leaking Underground Storage Tanks (LUST)
- Solid waste landfills, incinerators, or transfer stations (SWLF)
- Registered underground or aboveground storage tanks (UST/AST)
- RCRA registered large quantity generators of hazardous waste (LQG)
- RCRA registered small quantity generators of hazardous waste (SQG)
- Emergency Response Notification System of Spills (ERNS)
- State spills list

4.2.1 Impact Assessment Methodology

Each of the sites identified as a result of the database search was assigned a degree of priority for potential soil and/or groundwater impacts: "No", "Low", "Medium", or "High". Sites were initially assessed based on suspected shallow groundwater flow direction. Groundwater flow was evaluated based on topography and available hydrogeological maps from the Minnesota Geological survey. Sites considered to be hydraulically upgradient were included in the review. Sites considered hydraulically downgradient or side gradient were eliminated from further review. These ratings are generally based on the following criteria:

- "No" – After a review of all available information, there is no indication that the proposed project would impact the site. It is possible that potential contaminants could have been generated or handled on the proposed transit alternative; however, all information indicates potential impact should be minimal.
- "Low" – The former or current operation is identified as a large quantity hazardous waste generator, or the release and remediation of hazardous materials or petroleum products has been reported. However, based on available information, there is little indication of contamination currently on the identified site.
- "Medium" – After a review of available information, indications were found that identify known soil and/or groundwater contamination. Information may indicate that the contamination does not require remediation, is being remediated, or that continued monitoring is required. The ranking is established for each site within this category with regard to its acceptability for the proposed project, what action might be required if the site is acquired, and the possible alternatives that may be considered if there is need to avoid this site.
- "High" – After a review of available information, indications were found that identify a high probability of contamination associated with the site. Further assessment will be required after selection of the Locally Preferred Alternative (LPA) to determine the actual presence and/or levels of contamination, the contaminated medium and the need for mitigation. Actual physical assessment is not expected to begin until the final LPA is defined. Sites that are identified as "High" priority active environmental sites or LUST sites, and have not been previously evaluated or assessed, would receive the "High" priority ranking.

4.2.2 Potential Hazardous Materials Impacts

A total of 316 sites were identified during this database search as having the potential to impact the right-of-way under consideration for the proposed alternatives. These sites primarily contain hazardous materials, petroleum, or a combination of the two. Of these sites, four have been ranked as having a "High" potential for contamination, six ranked "Medium" and 153 ranked "Low". A summary of the environmental sites and their rankings is presented as Appendix 9.6. The total number of sites that have a potential to be impacted by the proposed project are summarized in Table 4.2-1: Hazardous Material Contamination Sites. Each of the "High" and Medium" ranked sites are discussed by alternative in the following paragraphs and illustrated on Figure 4.2-1: Hazardous Sites.

Table 4.2-1: Hazardous Material Contamination Sites

	Ranking Totals	
Alternatives	**"High"**	**"Medium"**
Baseline Alternative	0	0
LRT Alternative	4	6
BRT Alternative	3	4

SUMMARY OF IMPACTS BY ALTERNATIVE

Baseline Alternative

No significant impacts to identified hazardous material contamination sites are anticipated in association with the Baseline Alternative because it utilizes the existing network and only involves minor traffic engineering work rather than large roadway capacity expansions.

The majority of small-scale improvements included in the Baseline Alternative have already been completed. Only the rebuilding of a torn down bus garage in the Snelling Avenue Area and the construction of a noise wall near the interchange of I-94 and Victoria Street remain to be completed. Neither improvement is near an identified hazardous material contamination site.

University Avenue LRT Alternative

Six sites ranked "Medium" and four sites ranked "High" were identified along the proposed University Avenue LRT Alternative. Potential impacts associated with these "High" and "Medium" ranked sites are described in detail below.

Archer Daniels Midland, 419 29th Avenue SE, Minneapolis

This site is listed as a NFRAP site and as an active SPL site. According to the MPCA site manager, this site is in the final stage of remediation. The subsurface material consists of fill containing minor levels of lead and mercury. No significant impact to the groundwater was reported at this time. Based on this information, the site is considered "Medium" priority.

Reichhold Chemical, 525 25th Avenue SE and 601 25th Avenue SE, Minneapolis

This site is listed as a UST/AST site, a closed LUST site, a large quantity generator site, a state spills site and an active SCL site. No violations were found in relation to the site's hazardous waste generator status. According to the MPCA site manager, low levels of contaminants including Diesel Range Organics (DRO) are present at the site. However, no offsite contamination has been found. Based on this information, the site is considered "Medium" priority.

Mel Schroeder, Inc., One Malcolm Avenue Southeast, Minneapolis

This site is listed as a large quantity hazardous waste generator, and as an active SCL site. According to the MPCA site manager, low levels of contaminants including metals and polynuclear aromatic hydrocarbons (PAH) are present at the site. Remediation has not yet occurred and groundwater data are not currently available. Based on this information, the site is considered "Medium" priority.

Olson Graphic Products, 2446 and 2413-2425 University Avenue, St. Paul

This site is listed as an active SCL site and a small quantity hazardous waste generator. According to the MPCA site manager, only the surficial soil has been impacted with trichloroethylene (TCE). Contaminants are suspected to have migrated south of Olson Graphic Products. Limited amounts of data were available for this site. Based on this information, the site is considered "Medium" priority.

1919 University Avenue, St. Paul

This site is listed as an active SCL site. According to the MPCA site manager, chlorinated solvents were found in the soil and low concentrations of chlorinated solvent were found in groundwater at the site. The solvents were determined to have migrated from an off-site source. Based on this information, the site is considered "Medium" priority.

Harcross Chemical Company, 584 North Fairview Avenue, St. Paul

This site is listed as an UST/AST site, a large quantity hazardous waste generator, a SCL site, an ERNS site and a state spills site. No violations were found in relation to the site's hazardous waste generator status, and the ERNS and state spills cases have been considered closed by the MPCA. However, the site remains active as an SCL site. According to the MPCA site manager, Harcross is actively investigating a chlorinated solvent plume that has migrated southwest and offsite across University Avenue. Remediation has not been conducted at the site. Based on this information, the site is considered "High" priority.

Mowrey Company Surface Impoundment. – Area encompassed by University Avenue, Pascal Street, Albert Street, and Sherburne Avenue, St. Paul

This site was listed as a solid waste landfill site. According to the Ramsey County Environmental Health Department representative, the landfill contained metal from the refining method used by Mowrey Company and a small seepage pit that was filled in the 1980's. No documentation stating that the site has been remediated existed in the file. Based on this information, the site is considered "High" priority.

Autozone-University, 1061 University Avenue West, St. Paul

This site is listed as an active SCL site. According to the MPCA site manager, contaminants including PCBs are still present in the soil. Additional remediation must be conducted in order for this site to be eligible for a letter from the MPCA indicating no further remedial action is required. Based on this information, the site is considered "High" priority.

4th Street and Cedar Street, St. Paul

This site is listed as a closed LUST and an active SCL site. A "No Association" determination letter was issued in July of 2000. According to the MPCA site manager, contaminates including lead, mercury, PAH, and DRO were detected on the site. No remediation was conducted. Based on this information, the site is considered "Medium" priority.

Buckbee-Mears, 245 East 6th Street, St. Paul

This site is listed as a CORRACTS site, a RCRA TSD site, an ERNS site, a NFRAP site, a large quantity hazardous waste generator, a UST/AST site, a closed LUST site, and a state spills site. Attempts were made to recover additional information from the MPCA but the file could not be located by the MPCA. Due to the lack of available information and the numerous contamination issues this site is considered "High" priority.

University Avenue Busway/BRT Alternative

The BRT Alternative has the potential to impact identified hazardous material contamination sites only where the construction of stations or improvements is proposed. Four sites ranked "Medium" and three sites ranked "High" were identified along the BRT Alternative and near the proposed construction areas. The majority of these sites are described in detail under the University Avenue LRT Alternative. They include: Archer Daniels Midland, Olson Graphic Products, 1919 University Avenue, Harcross Chemical Company, Mowrey Company Surface Impoundment, and Autozone-University.

The following hazardous material contamination site has the potential to be impacted by the proposed University Avenue Busway/BRT Alternative and is not described under the LRT Alternative.

Riverview Area, Plato Boulevard/Robert Street, St. Paul

This site is listed as a SCL site. A No Association Determination Letter was received on January 30, 2001 and May 18, 2001. It is unknown if soil or groundwater at the site was impacted. Based on this information, the site is considered "Medium" priority.

Additional sites are identified as "High" and "Medium" priority in Appendix 9.6: Potential Hazardous Material Impacts, however they are not present near a proposed station modification or improvement and therefore do not have the potential to be impacted by the proposed Busway/BRT Alternative.

POTENTIAL IMPACTS SUMMARY

No "Medium" or "High" ranked sites are suspected to be impacted by the Baseline Alternative.

The proposed transit alternatives have the potential to impact the "High" and "Medium" ranked sources of potential environmental contamination determined in Section 4.2.2. The 10 sites that may be impacted by the University Avenue LRT Alternative include: Archer Daniels Midland, Reichhold Chemical, Mel Shroeder Inc., Olson Graphic Products, 1919 University Avenue, Harcross Chemical Company, Mowrey Company Surface Impoundment, Autozone-University, Fourth Street and Cedar Avenue, and Buckbee-Mears.

The seven sites that may be impacted by the University Avenue Busway/BRT Alternative include: Archer Daniels Midland, Olson Graphic Products, 1919 University Avenue, Harcross Chemical Company, Mowrey Company Surface Impoundment, Autozone-University, and Riverview Area.

4.2.3 Mitigation Measures

Following the selection of the Locally Preferred Alternative (LPA), the next phase of engineering work will include sampling and testing on the proposed transit alignment in the areas of the "Medium" and "High" priority sites to determine the potential for contamination and the mitigation costs associated with it. Additional potential sources of environmental contamination may be located along the Central Corridor that were not identified in the database search and therefore not included in this analysis. If encountered during subsequent engineering and construction phases they would be addressed at that time.

4.3 AIR QUALITY

The following section summarizes relevant air quality regulations and standards, evaluates the existing air quality in the study area and assesses the potential air quality impacts associated with this project.

4.3.1 Existing Conditions

The discussion of existing conditions includes a listing of the relevant pollutants, the National Ambient Air Quality Standards (NAAQS), the applicable regulations and a description of the level of maintenance in the Twin Cities region.

Relevant Pollutants

Motor vehicles emit a variety of pollutants including carbon monoxide (CO), nitrogen oxides (NO_X), particulate matter with a diameter of 10 microns or less (PM_{10}) and volatile organic compounds (VOCs). Another pollutant, ozone (O_3), is not a direct emission from automobiles (or other sources), but is formed in the atmosphere by chemical reactions involving hydrocarbons (HCs) and nitrogen oxides. CO is a pollutant of local concern with the highest concentrations generally occurring near heavily congested roadway intersections. O_3 problems tend to be regional in nature because the chemical reactions that produce O_3 occur over time.

Ambient Air Quality Standards

Under the authority of the Clean Air Act, United States Environmental Protection Agency (EPA) established a set of NAAQS for various "criteria" air pollutants. These standards are intended to protect the public health and welfare. Primary NAAQS are established at levels intended to protect the public health, including sensitive population groups, with an adequate margin of safety. Secondary NAAQS are set at levels designed to protect the public welfare by accounting for the effects of air pollution on vegetation, soil, materials, and other aspects of the general welfare. States can develop ambient air quality standards provided that they are at least as stringent as the National standards. Table 4.3-1: National and Minnesota Ambient Air Quality Standards, presents the NAAQS and the Minnesota Ambient Air Quality Standards (MAAQS) which are similar to the NAAQS. Compliance with these standards must be achieved by any project to be constructed in the State of Minnesota.

Table 4.3-1: National and Minnesota Ambient Air Quality Standards

Pollutant	Averaging Period	National Ambient Air Quality Standards[a]		Minnesota Ambient Air Quality Standards[a]	
		Primary	Secondary	Primary	Secondary
NO_2	Annual arithmetic mean	0.053 ppm[b] (100 $\mu g/m^3$)[c]	Same as primary.	0.053 ppm[b] (100 $\mu g/m^3$)[c]	Same as primary.
O_3[d]	1-Hour average	0.12 ppm (235 $\mu g/m^3$)[e]	Same as primary.	0.12 ppm (235 $\mu g/m^3$)	Same as primary.
CO	8-Hour average	9 ppm (10 mg/m^3)[g]	No standard.[f]	9 ppm (10 mg/m^3)	9 ppm (10 mg/m^3)
	1-Hour average	35 ppm (40 mg/m^3)	No standard.[f]	30 ppm (35 mg/m^3)	30 ppm (35 mg/m^3)
PM10[d]	Annual arithmetic mean	50 $\mu g/m^3$ [h]	Same as primary.	50 $\mu g/m^3$	Same as primary.
	24-our average	150 $\mu g/m^3$ [h]	Same as primary.	150 $\mu g/m^3$	Same as primary.
TSP	Annual geometric mean	No standard.[f]	No standard.[f]	75 $\mu g/m^3$	60 $\mu g/m^3$
	24-Hour average	No standard.[f]	No standard.[f]	260 $\mu g/m^3$	150 $\mu g/m^3$
SO_2	Annual arithmetic mean	80 $\mu g/m^3$ (0.03 ppm)	Same as primary.	80 $\mu g/m^3$ (0.03 ppm)	60 $\mu g/m^3$ (0.02 ppm)
	24-Hour average	365 $\mu g/m^3$ (0.14 ppm)[i]	Same as primary.	365 $\mu g/m^3$ (0.14 ppm)	Same as primary.
	3-Hour Average	No standard.	1,300 $\mu g/m^3$ (0.5 ppm)	1,300 $\mu g/m^3$ (0.5 ppm)	1300 $\mu g/m^3$ (0.5 ppm)[j]
	1-Hour Average	No standard.	No standard.	1,300 $\mu g/m^3$ (0.5 ppm)	No standard.
Lead	Quarterly mean	1.5 $\mu g/m^3$	Same as primary.	1.5 $\mu g/m^3$	Same as primary.

Notes:

a Short-term standards (1 to 24 hours) are not to be exceeded more than once per calendar year.

b ppm: parts per million.

c $\mu g/m^3$: micrograms per cubic meter.

d In 1997, EPA promulgated new NAAQS for O_3 (8-hour average) and particulate matter of 2.5 microns diameter or smaller ($PM_{2.5}$). Minnesota promulgated similar standards. These standards are subject to continuing judicial challenges. In May 1999, the U.S. Court of Appeals for the District of Columbia Circuit invalidated portions of the rules establishing these new standards. However, in February 2001, the Supreme Court overruled the Circuit Court's decision on a number of grounds and remanded the case back to the Circuit Court for further proceedings. In the interim, the new standards have not been vacated but also are not being implemented. EPA has not designated areas in attainment or nonattainment of the new standards.

e Maximum daily 1-hour average. The O_3 standard is attained when the expected number of days with maximum hourly average concentrations above the value of the standard, averaged over a three-year period, is less than or equal to one.

f Former national secondary standards for CO, and former national primary and secondary standards for TSP, have been repealed.

g mg/m^3: milligrams per cubic meter.

h The PM_{10} standard is attained when the expected number of days with maximum average concentrations above the value of the standard, averaged over a three-year period, is less than or equal to one.

i National standards are block averages rather than moving averages.

j Minnesota secondary standard for SO_2 (Sulfur Dioxide) varies by region. Value of 1,300 $\mu g/m^3$ applies to the Minneapolis-St. Paul Intrastate Air Quality Control Region (AQCR number 131) including the project corridor.

Not shown: Minnesota standards for hydrogen sulfide (H_2S). Transportation sources do not emit significant amounts of H_2S, and therefore H_2S is not assessed in the EIS.

Sources: National – 40 CFR 50, Section 121; Minnesota – Minnesota Rules, Part 7009.0080.

Air Quality Regulations and Planning

Public awareness of the effects of air pollution has increased noticeably in recent years. This concern resulted in the passage of the Federal Clean Air Act of 1970, as amended in 1977 and 1990. These statutes are the basis for most federal air pollution control programs. The Minnesota State Implementation Plan (SIP), developed under the Clean Air Act, as amended, contains the major State-level requirements with respect to the project.

Air quality is regulated nationally by the EPA under the Clean Air Act. The EPA delegates authority to the MPCA for monitoring and enforcing air quality regulations in Minnesota. MPCA is responsible for preparing the SIP and submitting it to EPA for approval. The project corridor is within the geographic jurisdiction of the Twin Cities Metropolitan Council, which has responsibilities related to transportation and air quality planning in the Twin Cities region. Because the Twin Cities region has been designated maintenance for CO, transportation plans and projects in the region must conform to the SIP.

Ambient Air Quality in the Project Area

This section summarizes measured ambient air quality data for the region including the project corridor. MPCA maintains a statewide network of monitoring stations that routinely measure pollutant concentrations in the ambient air, and provide data to assess compliance with the NAAQS and MAAQS and to evaluate the impact of pollution control strategies. The monitored pollutants of concern in this analysis are O_3, NO_2, CO, PM_{10}, and SO_2. Table 4.3-2: 2001 Measured Ambient Concentrations in the Central Corridor Region, presents the maximum measured concentrations for these pollutants measured at the nearest representative monitoring stations to the project corridor, as reported by MPCA for the most recent full year of data (2001). These data can be compared to the NAAQS and MAAQS.

Table 4.3-2: 2001 Measured Ambient Concentrations in the Central Corridor Region

Pollutant	Averaging Period	Nearest Station to Project Corridor	2001 Measured Data*
Nitrogen Dioxide	Annual	2077 West Larpenteur Ave., St. Paul	0.017 ppm
Ozone	1 Hour	11660 Myeron Rd, North, Stillwater	0.112 ppm
Carbon Monoxide (four monitoring stations for CO are located within the project corridor)	1 Hour	528 Hennepin Ave., Minneapolis	4.9 ppm
	8 Hours		2.3 ppm
	1 Hour	1549 West University Ave., St. Paul	6.0 ppm
	8 Hours		3.8 ppm
	1 Hour	1088 West University Ave., St. Paul	11.4 ppm
	8 Hours		8.6 ppm
	1 Hour	10th St. & Wabasha Ave., St. Paul	6.1 ppm
	8 Hours		3.3 ppm
PM_{10}	24 Hours	300 Nicollet Mall, Minneapolis	56.0 $\mu g/m^3$
	Annual		28.9 $\mu g/m^3$
Sulfur Dioxide	3 Hours	528 Hennepin Ave., Minneapolis	0.082 ppm
	24 hours		0.036 ppm
	Annual		0.002 ppm
Lead	Quarterly	300 Nicollet Mall, Minneapolis	0.01 $\mu g/m^3$

Notes:

* $\mu g/m^3$ means micrograms per cubic meter; ppm means parts per million. Annual data are arithmetic means; other values are maximums for the averaging periods indicated. Measured values may be compared to the standards shown in Table 4.3.1.

Source: MPCA, as reported to U.S. Environmental Protection Agency AIRData website (http://www.epa.gov/air/data). *Monitor Values Report* accessed January 16, 2002.

As shown in Table 4.3-2, the highest one-hour O_3 concentration in the region near the project corridor in 2001 was 0.112 ppm measured at the monitoring station in Stillwater. This level is below the one-hour O_3 standard of 0.12 ppm. There were no exceedances of the O_3 standard at the Stillwater station site in 2001. This area of Minnesota is currently classified as in attainment for O_3.

The highest annual average NO_2 concentration near the project corridor in 2001 was 0.017 ppm measured at the monitoring station located at 2077 West Larpenteur Avenue, St. Paul. This level is below the annual NO_2 standard of 0.05 ppm. The entire state of Minnesota is currently classified as in attainment for NO_2.

The highest one-hour average CO concentration near the project corridor in 2001 was 11.4 ppm measured at the monitoring station located at 1088 West University Avenue, St. Paul. This level is below the one-hour NAAQS of 35 ppm and the one-hour MAAQS of 30 ppm. The highest measured eight-hour average CO concentration, which occurred at the same station, was 8.6 ppm. This level is below the eight-hour CO standard of 9 ppm. Hennepin and Ramsey Counties are currently classified as maintenance for CO.

The highest measured 24-hour average PM_{10} concentration near the project corridor in 2001, recorded at the monitoring station at 300 Nicollet Mall, Minneapolis, was 56 micrograms per cubic meter (μg/m3). This level is below the 24-hour PM_{10} standard of 150 μg/m3. The measured annual average PM_{10} concentration, which occurred at the same station, was 28.9 μg/m3. This level is below the annual PM_{10} standard of 50 μg/m3. Hennepin and Ramsey Counties are currently in attainment for PM_{10}, except for a small PM_{10} nonattainment area in Ramsey County that is not within the project corridor.

The highest measured 3-hour average SO_2 concentration near the project corridor in 2001, recorded at the monitoring station located at 528 Hennepin Avenue, Minneapolis, was 0.082 ppm. This level is below the 3-hour SO_2 secondary standard of 0.5 ppm. The highest measured 24-hour average SO_2 concentration in 2001, recorded at the same station, was 0.036 ppm. This level is below the 24-hour SO_2 standard of 0.14 ppm. The measured annual average SO_2 concentration was 0.02 ppm. This level is below the annual SO_2 standard of 0.03 ppm. Hennepin and Ramsey Counties are currently in attainment for SO_2.

4.3.2 Air Quality Analysis

The air quality analysis consists of three components: an emissions inventory for CO, VOC, and NO_x, and a hot-spot (dispersion modeling) analysis to estimate maximum one-hour and eight-hour CO concentrations at selected roadway intersections in the study area. Motor vehicles produce most of the ambient CO, and emission rates of CO from vehicles are relatively high compared to emissions of other pollutants. The values of the NAAQS and MAAQS are such that, should adverse impacts occur due to local sources, the CO standard would be most likely to be exceeded first. Accordingly, CO is used to indicate the potential for localized adverse air quality impacts from motor vehicles in general and at roadway intersections in particular. Emissions were evaluated for the existing conditions in 2000, and concentrations were evaluated for the existing conditions in 2001, consistent with the project traffic studies. Future conditions were evaluated in the opening year of 2008 and the design year of 2020, for the Baseline, University Avenue LRT and University Avenue Busway/BRT Alternatives.

EMISSIONS INVENTORY ANALYSIS

Emissions inventories are quantities of pollutants emitted over a given time period, which provide information about contributions from various sources. Region-wide motor vehicle emission inventories of CO, VOC, and NO_x were developed for the 2000 Existing Conditions, and the future Baseline Conditions and the two Build Alternatives in 2008 and 2020.

Emission Inventory Analysis Methods

Emissions are estimated by multiplying emission factors by source activity levels. Emission factors are the emissions from a single source for a unit of time or distance (e.g., grams of CO for one automobile traveling one mile). The source activity for such a factor would be vehicle-miles-traveled (VMT) by roadway segment in a given time period, such as one day. The emission inventories were estimated for emissions sources in the Project Study Area for an average 24-hour period in accordance with guidance issued by the EPA. Emissions were calculated by multiplying the 24-hour Average Daily Traffic (ADT) VMTs by the speed-dependent emission factor for each road segment in the project Study Area. Individual roadway segments are defined by the links in the regional travel demand model. Total annual project-related emissions were determined by summing the emissions from each of the individual link segments in the Study Area and then multiplying by 365 days per year.

Emission factors (in grams/VMT) were used to compute the activity-specific emission rates for use in the emission inventory and dispersion modeling analysis. Emission factors for these computations are based on EPA databases and methodologies. The emission factors that were used to compute the emission rates were generated using EPA's approved emissions factors program MOBILE5b, which was the most recent version of the MOBILE program at the time the air quality analysis commenced. Idling emission factors for CO were developed using the recommended procedure contained in EPA's MOBILE5 Information Sheet #2. The input parameter values for MOBILE5b were selected in accordance with MPCA guidance, and are shown in Table 4.3-3: Major Input Parameters for MOBILE5b Emission Factor Modeling.

EMISSIONS INVENTORY RESULTS

Year 2000 Existing Conditions

Emissions for the 2000 Existing Conditions were estimated for CO, VOC and NO_x for the project transportation study area, and the results are presented in Table 4.3-4: Emissions Inventory (tons/year) for the Project Study Area. For the 2000 Existing Conditions, region-wide emissions are estimated to be 372,778 tons/year of CO; 43,055 tons/year of VOC; and 58,786 tons/year of NO_x.

Baseline Alternative

CO, VOC, and NO_x emissions for the 2008 Baseline Alternative were estimated and the results are presented in Table 4.3-4. For the 2008 Baseline Alternative, region-wide emissions are estimated to be 352,853 tons/year of CO; 41,580 tons/year of VOC; and 56,745 tons/year of NO_x. Emissions of all three pollutants are lower in the 2008 Baseline Conditions than in the 2000 Existing Conditions because increases in the traffic volumes due to regional growth are more than offset by the reductions in motor vehicle emissions as required by the Federal Motor Vehicle Emission Control Program (FMVECP) under the Clean Air Act. The FMVECP mandates increasingly effective emission controls on successive model year vehicles. As new vehicles replace older ones over time the average emission rates per vehicle decrease.

Table 4.3-3: Major Input Parameters for MOBILE5b Emission Factor Modeling

Parameter Description	Values Used in Modeling	
Vehicle mix	National default	
Mileage accrual rates	National defaults	
Vehicle age distribution	MPCA values for 1990	
Operating modes	National defaults	
Non-catalyst cold start	20.6%	
Catalyst hot start	27.3%	
Catalyst cold start	20.6%	
Region	Low altitude	
Inspection/Maintenance Program	None	
Anti-tampering program	None	
Month of evaluation	VOC and NO_x	CO
	July	January
Ambient Temperatures	VOC and NO_x	CO
Minimum	72.0° F	16.0° F
Maximum	92.0° F	38.0° F
Ambient	85.0° F	31.0° F
Local Area Parameters	VOC and NO_x	CO
Gasoline ASTM class	C	C
RVP Period 1 (Base)	9.0 psi	9.0 psi
RVP Period 2	9.0 psi	9.0 psi
Oxygenated fuels	Yes	Yes
Reformulated gasoline	No	No
Detergent gasoline	Default effects	Default effects

Table 4.3-4: Emissions Inventory (tons/year) for the Project Study Area

Year and Project Alternative	CO	VOC	NO_x
2000 Existing Conditions	372,778	43,055	58,786
2008 Baseline Alternative	352,853	41,580	56,745
2008 LRT Alternative	350,787	41,402	56,752
2008 BRT Alternative	350,577	41,397	56,760
2020 Baseline Alternative	414,038	46,829	66,958
2020 LRT Alternative	411,572	46,629	66,968
2020 BRT Alternative	411,324	46,622	66,972

CO, VOC, and NO_x emissions for the 2020 Baseline Alternative were estimated and the results are also presented in Table 4.3-4. For the 2020 Baseline Alternative, region-wide emissions are estimated to be 414,038 tons/year of CO; 46,829 tons/year of VOC; and 66,958 tons/year of NO_x. Emissions of all three pollutants are higher in the 2020 Baseline Alternative than in the 2000 Existing Conditions because increases in the traffic volumes due to regional growth more than offset the emission reductions in motor vehicle emissions achieved by the FMVECP. Similarly, emissions of all three pollutants are higher in the 2020 Baseline Alternative than in the 2008 Baseline Alternative because increases in the traffic volumes due to regional growth more than offset the emission reductions in motor vehicle emissions achieved by the FMVECP.

University Avenue LRT Alternative

Estimated emissions of CO, VOC, and NO_x for the 2008 LRT Alternative are shown in Table 4.3-4. For the 2008 LRT Alternative, region-wide emissions are estimated to be 350,787 tons/year of CO; 41,402 tons/year of VOC; and 56,752 tons/year of NO_x. Emissions of all three pollutants are lower in the 2008 LRT Alternative than in the 2000 Existing Conditions primarily because increases in the traffic volumes are more than offset by the reductions in motor vehicle emissions achieved by the FMVECP. Emissions of both VOC and CO in the 2008 LRT Alternative are lower than in the 2008 Baseline Alternative, while NO_x emissions are slightly higher. These differences are due to a small decrease in VMT due to the project as passengers choose to use the LRT instead of driving. Small changes in the distribution of VMT and average travel speeds on various roadways in the region combine to increase NO_x emissions slightly even as CO and VOC emissions decrease slightly.

Estimated emissions of CO, VOC, and NO_x for the 2020 LRT Alternative are shown in Table 4.3-4. For the 2020 LRT Alternative, region-wide emissions are estimated to be 411,572 tons/year of CO; 46,629 tons/year of VOC; and 66,968 tons/year of NO_x. Emissions of all three pollutants are higher in the 2020 LRT Alternative than in the 2000 Existing Conditions primarily because increases in the traffic volumes more than offset the reductions in motor vehicle emissions achieved by the FMVECP. Emissions of both VOC and CO in the 2020 LRT Alternative are slightly lower than in the 2020 Baseline Alternative, while NO_x emissions are slightly higher. These differences are due to a small decrease in VMT due to the project as passengers choose to use the LRT instead of driving. Small changes in the distribution of VMT and average travel speeds on various roadways in the region combine to increase NO_x emissions slightly even as CO and VOC emissions decrease slightly.

*University Avenue Busway/*BRT Alternative

Estimated emissions of CO, VOC, and NO_x for the 2008 BRT Alternative are shown in Table 4.3-4. For the 2008 BRT Alternative, region-wide emissions are estimated to be 350,577 tons/year of CO; 41,397 tons/year of VOC; and 56,760 tons/year of NO_x. Emissions of all three pollutants are lower in the 2008 BRT Alternative than in the 2000 Existing Conditions primarily because increases in the traffic volumes are more than offset by the reductions in motor vehicle emissions achieved by the FMVECP. Emissions of both VOC and CO in the 2008 BRT Alternative are lower than in the 2008 Baseline Alternative, while NO_x emissions are slightly higher. These differences are due to slight changes in the distribution of VMT and average travel speeds on various roadways in the region. These changes combine to increase NO_x emissions slightly even as CO and VOC emissions decrease slightly. Also contributing to these results is a slight decrease in regional VMT due to the project as passengers choose to use the BRT instead of driving.

Estimated emissions of CO, VOC, and NO_x for the 2020 BRT Alternative are also shown in Table 4.3-4. For the 2020 BRT Alternative, region-wide emissions are estimated to be 411,324 tons/year of CO; 46,622 tons/year of VOC; and 66,972 tons/year of NO_x. Emissions of all three pollutants are higher in the 2020 BRT Alternative than in the 2000 Existing Conditions primarily because increases in the traffic volumes more than offset the reductions in motor vehicle emissions achieved by the FMVECP. Emissions of both VOC and CO in the 2020 BRT Alternative are slightly lower than in the 2020 Baseline Alternative, while NO_x emissions are slightly higher. These differences are due to a small decrease in VMT due to the project as passengers choose to use the BRT instead of driving. Small changes in the distribution of VMT and average travel speeds on various roadways in the region combine to increase NO_x emissions slightly even as CO and VOC emissions decrease slightly.

Although both the LRT Alternative and the BRT Alternative would reduce CO and VOC emissions in 2008 compared to the Baseline Alternative, total CO and VOC emissions with the LRT Alternative would be slightly higher than with the BRT Alternative. On the other hand, the LRT Alternative would have slightly lower NO_x emissions than the BRT Alternative. These differences are due to several factors. Both build alternatives would decrease regional automobile VMT, but the VMT decrease is less with the BRT Alternative than with the LRT Alternative. Also, the BRT Alternative includes the additional VMT accrued by the BRT vehicles. The net result is that the BRT Alternative would increase total VMT slightly while the LRT Alternative would decrease total VMT slightly, compared to the Baseline Alternative. Small changes in the distribution of VMT and average travel speeds on various roadways in the region combine to increase NO_x emissions slightly even as CO and VOC emissions decrease slightly. The BRT vehicles, which have relatively high NOx emission rates and are present only in the BRT Alternative, also contribute to the greater NO_x increase with the BRT Alternative compared to the LRT Alternative.

Compared to the BRT Alternative, the LRT Alternative in 2020 would have slightly higher CO and VOC emissions, and slightly lower NO_x emissions. As in 2008, these differences are due to a slight variation in total VMT between the alternatives, the distribution of VMT and average travel speeds on various roadways in the region, and the VMT and emissions contributed by the BRT vehicles in the BRT Alternative.

MICROSCALE ANALYSIS

This section describes the microscale analysis of selected intersections located in the Study Area.

Microscale Analysis Methods

Motor vehicles emit CO at the highest rates when they are operating at low speeds or idling in queues. For this reason, the potential for adverse air quality impacts is greatest at intersections where traffic is most congested. EPA has specified criteria based on traffic level of service (LOS) and volume for screening the intersections in the study area and selecting intersections for detailed air quality analysis. LOS is a measure of the performance of the intersection in processing the volume of vehicles attempting to pass through it. LOS is expressed as a letter rating based on the amount of overall delay at the intersection, where LOS A is best and LOS F worst.

Selection of Locations to be Analyzed

The EPA's LOS criterion states that intersections that currently operate at LOS D or worse, or would operate at LOS D or worse under future conditions, should be considered for air quality analysis. The candidate signalized intersections in the traffic study area were ranked by LOS and by total volume in accordance with the EPA's guidelines. The five intersections with the worst LOS and the highest volumes were selected for detailed air quality analysis. Table 4.3-5: Intersections Modeled for Air Quality Impacts, lists the intersections that were selected.

Table 4.3-5: Intersections Modeled for Air Quality Impacts

ID Number	Intersection Description
1	University Avenue and Snelling Avenue
2	University Avenue and Lexington Parkway
3	University Avenue and Marion Street
4	University Avenue and Rice Street
5	University Avenue and Robert Street

Receptor Locations

At each of the intersections selected for the detailed modeling analysis, maximum one-hour and eight-hour CO concentrations were estimated at several locations (known as receptors) in the vicinity of the intersection, where the maximum concentrations would be expected and the public would have reasonable access. In accordance with EPA's 1992 guidelines, receptors were placed in the sidewalk area on both sides of each approach of each intersection, outside of the mixing zones of the free-flow links being modeled. Where applicable, additional receptors were placed at nearby locations with sensitive land uses such as residences, businesses, and other areas where the public would have access.

Dispersion Modeling

Maximum one-hour CO concentrations were estimated with EPA's CAL3QHC Version 2.0 dispersion model (dated June 1993). Consistent with EPA's 1992 guidelines and MPCA guidance, eight-hour CO concentrations were estimated by multiplying the modeled one-hour results by a persistence (scale) factor of 0.7. Total CO concentrations were derived by adding to the modeled maximum concentrations a background level to account for sources of CO other than the traffic at the intersection being modeled. Background levels of 5.0 ppm for one hour and 3.0 ppm for eight hours were used in accordance with EPA and MPCA guidance. These background concentrations were held constant for all analysis years and project alternatives. When executing the CAL3QHC, Version 2 model, the additional assumptions listed in Table 4.3-6: Input Parameter Assumptions for CAL3QHC Dispersion Modeling, were used.

Table 4.3-6: Input Parameter Assumptions for CAL3QHC Dispersion Modeling

Parameter Description	Value
Surface roughness coefficient (Z_0)	321 cm (central business district [CBD]/high-rise buildings)
Design saturation flow rate (SFR)	1600 vehicles/hour
Arrival rate (AT)	3 (random arrivals)
Signal type (ST)	2 (actuated, reflects actual conditions)
Wind speed	1 meter/second
Pasquill-Gifford stability class	D (Neutral)
Mixing height	1000 meters
Wind directions	10 - 360 degrees scanned at 10-degree increments

MICROSCALE ANALYSIS RESULTS

Existing Conditions

Maximum one- and eight-hour CO concentrations were estimated for the Existing Conditions in 2001, as shown in Table 4.3-7: Estimated Maximum One-Hour CO Concentrations for Project Alternatives at Roadway Intersections, respectively, to indicate air quality trends at the intersections over time. The maximum estimated CO concentrations with the 2001 Existing Conditions occurred at a receptor at the intersection of University and Lexington Parkway. At this receptor, located 3 meters from the head of the queue on the Lexington Parkway northbound approach, the maximum one-hour level was 12.9 ppm and the maximum 8-hour level was 8.5 ppm. As Table 4.3-7 indicates, all estimated CO concentrations for the 2001 Existing Conditions are less than the NAAQS of 35 ppm and the MAAQS of 30 ppm for one hour, and the NAAQS and MAAQS of 9 ppm for eight hours.

Table 4.3-7: Estimated Maximum One-Hour CO Concentrations for Project Alternatives at Roadway Intersections

I.D. No.	Intersection Description	2001 Existing Conditions	2008 Baseline Alt.	2008 LRT Alt.	2008 BRT Alt.	2020 Baseline Alt.	2020 LRT Alt.	2020 BRT Alt.
One-Hour CO Concentrations[1/] (ppm)								
1	University Avenue and Snelling Avenue	12.7	12.0	12.6	12.6	12.7	12.8	12.8
2	University Avenue and Lexington Parkway	12.9	12.3	13.3	13.3	12.9	13.5	13.5
3	University Avenue and Marion Street	11.5	11.0	11.4	11.4	11.8	11.8	11.8
4	University Avenue and Rice Street	10.7	10.5	11.2	11.2	10.9	11.4	11.4
5	University Avenue and Robert Street	10.9	10.5	9.0	10.5	11.1	9.4	11.1
Eight-Hour CO Concentrations[2/] (ppm)								
1	University Avenue and Snelling Avenue	8.4	7.9	8.3	8.3	8.4	8.5	8.5
2	University Avenue and Lexington Parkway	8.5	8.1	8.8	8.8	8.5	8.9	8.9
3	University Avenue and Marion Street	7.5	7.2	7.5	7.5	7.8	7.8	7.8
4	University Avenue and Rice Street	7.0	6.8	7.3	7.3	7.1	7.5	7.5
5	University Avenue and Robert Street	7.1	6.8	5.8	6.8	7.3	6.1	7.3

Notes:

1/ One-hour CO concentrations include a background level of 5.0 ppm. The one-hour NAAQS is 35 ppm and the one-hour MAAQS is 30 ppm.

2/ Eight-hour CO concentrations include a background level of 3.0 ppm. The eight-hour NAAQs and MAAQS are 9 ppm.

Baseline Alternative

Table 4.3-7 shows the maximum estimated one-hour and eight-hour CO concentrations for the Baseline Alternative, respectively. The maximum estimated CO concentrations with the 2008 Baseline Alternative occurred at a receptor at the intersection of University and Lexington Parkway. At this receptor, located 3 meters from the head of the queue on the Lexington Parkway northbound approach, the maximum one-hour level was 12.3 ppm and the maximum 8-hour level was 8.1 ppm. Compared to the 2000 existing conditions, CO concentrations decrease with the 2008 Baseline Alternative because of the FMVCECP. As new vehicles replace older ones over time the average CO emission rate per vehicle decreases. This decrease in emission factors offsets the growth in traffic volumes from 2001 to 2008. In 2020, the maximum CO concentrations were 12.9 ppm for one hour and 8.5 ppm for eight hours. CO concentrations increase from 2008 to 2020 because continued growth in traffic volumes offsets the decrease in emission factors. As Table 4.3-7 indicates, all estimated CO concentrations with the Baseline Alternative are less than the NAAQS of 35 ppm and the MAAQS of 30 ppm for one hour, and the NAAQS and MAAQS of 9 ppm for eight hours.

University Avenue LRT Alternative

Table 4.3-7 shows the maximum estimated one-hour and eight-hour CO concentrations for the LRT Alternative, respectively. The maximum estimated CO concentrations with the 2008 LRT Alternative occurred at a receptor at the intersection of University and Lexington Parkway. At this receptor, located 3 meters from the head of the queue on the Lexington Parkway northbound approach, the maximum one-hour level was 13.3 ppm and the maximum 8-hour level was 8.8 ppm. Compared to the Baseline Alternative, CO concentrations increase in 2008 with the LRT Alternative because the addition of the LRT line decreases the capacity of the intersection, which increases vehicle delays and queuing, and increases the associated emissions. In 2020, the maximum CO concentrations were 13.5 ppm for one hour and 8.9 ppm for eight hours. These estimated concentrations probably overestimate the actual air quality impacts because the project traffic studies did not assume any decrease in volumes at the modeled intersections as a result of diversion of travelers from automobiles to LRT. The estimated CO concentrations are the same for the LRT Alternative and the BRT Alternative in both 2008 and 2020, because the project impacts on intersection geometry and traffic volumes are the same for both alternatives. However, it is anticipated that CO levels will be reduced as a result of diverting trips from autos to either build alternative. As Table 4.3-7 indicates, all estimated CO concentrations with the LRT Alternative are less than the NAAQS of 35 ppm and the MAAQS of 30 ppm for one hour, and the NAAQS and MAAQS of 9 ppm for eight hours.

*University Avenue Busway/*BRT Alternative

Table 4.3-7 shows the maximum estimated one-hour and eight-hour CO concentrations for the BRT Alternative, respectively. The maximum estimated CO concentrations with the 2008 BRT Alternative occurred at a receptor at the intersection of University and Lexington Parkway. At this receptor, located 3 meters from the head of the queue on the Lexington Parkway northbound approach, the maximum one-hour level was 13.3 ppm and the maximum 8-hour level was 8.8 ppm. Compared to the Baseline Alternative, CO concentrations increase in 2008 with the BRT Alternative because the addition of the busway decreases the capacity of the intersection, which increases vehicle delays and queuing, and increases the associated emissions. In 2020, the maximum CO concentrations were 13.5 ppm for one hour and 8.9 ppm for eight hours. These estimated concentrations probably overestimate the actual air quality impacts because the project traffic studies did not assume any decrease in volumes at the modeled intersections as a result of diversion of travelers from automobiles to BRT. Changes are minor due to the fact that increase in automobile traffic is greater than the number of trips diverted to LRT or BRT modes. As Table 4.3-7 indicates, all estimated CO concentrations with the BRT Alternative are less than the NAAQS of 35 ppm and the MAAQS of 30 ppm for one hour, and the NAAQS and MAAQS of 9 ppm for eight hours.

4.3.3 Construction Air Quality Impacts

Direct emissions from construction equipment would not be expected to produce adverse effects on local air quality, provided that all equipment is properly operated and maintained. Appropriate mitigation requirements could consist of assurance of proper operation and maintenance, specification of low-emissions equipment (EPA Tier 2 compliant, alternative-fueled, or retrofit with emissions controls), and prohibition of excessive idling of engines.

Increased emissions from traffic congestion due to lane closures, detours, and construction vehicles accessing the sites can be mitigated by implementing appropriate traffic management techniques during the construction period. Examples of these techniques include development of site-specific traffic management plans; temporary signage and other traffic controls; designated staging areas, worker parking lots (with shuttle bus service if necessary), and truck routes; and prohibition of construction vehicle travel during peak traffic periods.

Fugitive dust impacts can be mitigated through good "housekeeping" practices such as water sprays during demolition; wetting, paving, landscaping, or chemically treating exposed earth areas; covering dust-producing materials during transport; limiting dust-producing construction activities during high wind conditions; and providing street sweeping and tire washes for trucks leaving the site. MPCA regulations require mitigation of fugitive dust emissions.

4.3.4 Mitigation Measures for Project Operation

With respect to regional air quality impacts and transportation conformity, the project will reduce CO emissions slightly with either the LRT Alternative or the BRT Alternative, compared to the Baseline Alternative, in both 2008 and 2020. Therefore, no mitigation measures are necessary in order to demonstrate project-level conformity of the project-related emissions inventory.

With respect to localized air quality impacts, the modeled one-hour and eight-hour CO concentrations were compared to the NAAQS and the MAAQS. In order to demonstrate compliance with the ambient CO standards, predicted CO concentrations must not equal or exceed the NAAQS. All estimated CO concentrations are less than the NAAQS and the MAAQS for both build alternatives in both future years. Therefore, no mitigation measures are necessary with respect to compliance with the NAAQS and the MAAQS. As described above, construction impacts can be minimized with appropriate mitigation measures.

4.3.5 Conclusions

The impacts of either the LRT Alternative or the BRT Alternative on regional emissions will be slight. The project will reduce CO and VOC emissions slightly with either the LRT Alternative or the BRT Alternative, compared to the Baseline Alternative, in both 2008 and 2020. Emissions of NO_x will increase slightly due to the project; however, the increases are negligible and there is no regulatory requirement that the project reduce NO_x emissions. All estimated CO concentrations are less than the NAAQS and the MAAQS. Therefore, no mitigation measures are necessary.

Because the project-level emissions inventory has shown that the LRT Alternative and the BRT Alternative will reduce CO emissions, and the hot-spot analysis has shown that there will be no violations of the NAAQS or the MAAQS, the project conforms to the requirements of the transportation conformity rules.

The differences in air quality impacts between the build alternatives are negligible. Because the region is classified as attainment/maintenance for CO, the transportation conformity requirements apply to CO emissions, and compliance with the NAAQS and MAAQS for CO may be considered to be of more immediate priority than for VOC and NO_x. From the perspective of minimizing CO region wide, the BRT Alternative provides a slightly greater benefit than the LRT Alternative.

Construction activities have the potential to produce short-term, localized air quality impacts. These potential impacts can be minimized with appropriate mitigation measures as discussed above.

4.4 NOISE AND VIBRATION

This section includes an introduction to basic noise concepts including noise descriptors, the prediction methodologies and modeling assumptions, the results of the ambient noise monitoring program, and the evaluation of potential impacts along the Central Corridor.

4.4.1 Human Perception of Noise

The characteristics and properties of noise are explained in the following subsections.

DESCRIBING NOISE

Noise is "unwanted sound" and, by this very definition, the perception of noise is a subjective process. Several factors affect the actual level and quality of sound (or noise) as perceived by the human ear and can generally be described in terms of loudness, pitch (or frequency), and time variation.

- Loudness. The loudness, or magnitude, of noise determines its intensity and is measured in decibels (dB). The noise dB is used to describe a large range of sound levels. For example, ambient noise ranges from 40-dBs from the rustling of leaves to over 70-dBs from a truck passby to over 100-dBs from a rock concert.
- Pitch. Pitch describes the character and frequency content of noise. Measured in Hertz (Hz), frequency is typically used to identify the annoying characteristics of noise and thereby identify the proper mitigation to help eliminate or minimize its magnitude. The human ear is typically sensitive to noise frequencies between 20 Hz (low-pitched noise) and 20,000 Hz (high-pitched noise). For example, noise may range from very low-pitched "rumbling" noise from stereo sub-woofers to mid-range traffic noise to very high-pitched whistle noise.
- Time Variation. The time variation of some noise sources can be characterized as continuous, such as a building ventilation fan, intermittent, such as for a train passby, or impulsive, like a car backfire.

DESCRIPTION OF NOISE LEVELS

Various levels are used to quantify noise from transit sources including a sound's loudness, duration, and tonal character. For example, the A-weighted decibel (dBA) is commonly used to describe the overall noise level. Because the dB is based on a logarithmic scale, a 10-dB increase in noise level is generally perceived as a doubling of loudness, while a 3-dB increase in noise is just barely perceptible to the human ear. The A-weighting is an attempt to take into account the human ear's response to audible frequencies. Typical A-weighted sound levels from transit and other common sources are shown in Figure 4.4-1: Typical A-weighted Noise Levels. The following A-weighted noise descriptors are typically used to determine impacts from transit-related sources:

- L_{max} represents the maximum noise level that occurs during an event or train passby and is the noise level actually heard during the event or passby.
- L_{eq} represents a level of constant noise with the same acoustical energy as the fluctuating noise levels (e.g., highway traffic) observed during a given interval such as one hour. For transit projects the L_{eq} noise level is commonly used to describe levels at non-residential places (such as offices, schools, and churches) with primarily daytime uses. L_{eq}(h) is a noise level averaged over one hour.
- L_{dn}, the day-night noise level, represents the average noise level evaluated over a 24-hour period. A 10-dB penalty is added to events that occur during the nighttime hours (10:00 PM to 7:00 AM) to account for people's increased sensitivity to noise while they are sleeping. For transit projects the L_{dn} is commonly used to describe noise at residences.
- SEL is the sound exposure level typically used to predict overall transit source levels. The SEL converts the time period of the L_{eq} to one second allowing for the direct comparison of events or passbys with different time durations.

Unlike the L_{max} level, the hourly L_{eq} noise level describes noise over a longer time duration than just a single event. For example, a single six-car train passby at 50 mph has an L_{max} of 88 dBA but a L_{eq}(h) level of only 54 dBA. This is due to the concept of time averaging whereby the overall average noise level (L_{eq}) during the one-hour period is much less than the short-duration passby level of the event (L_{max}). The L_{max} and the hourly L_{eq} levels are theoretically equivalent for constant noise sources such as transformers or rooftop ventilation units.

4.4.2 Noise Evaluation Criteria

The criteria used to evaluate operational noise impacts are described in the following subsections.

OPERATIONAL NOISE

Operational criteria are used to assess noise impacts from the project alternatives when they are fully operational. These criteria are, therefore, typically evaluated against the project operations that occur in the design year.

FEDERAL NOISE GUIDELINES

The Federal Transit Administration's (FTA's) *Transit Noise and Vibration Impact Assessment* guidance manual (Department of Transportation [DOT]-95-16, April 1995) presents the basic concepts, methods, and procedures for evaluating the extent and severity of noise impacts from transit projects. Transit noise impacts are assessed based on land use categories and sensitivity to noise from transit sources under the FTA guidelines. The FTA noise impact criteria are defined by two curves that allow increasing project noise levels as existing noise increases up to a point, beyond which impact is determined based on project noise alone. The FTA land use categories and required noise metrics is described in Table 4.4-1: FTA Land Use Categories and Noise Metrics.

The FTA noise criteria are delineated into two categories: *impact* and *severe impact*. The *impact* threshold defines areas where the change in noise is noticeable but may not be sufficient to cause a strong, adverse community reaction. The *severe impact* threshold defines the noise limits above which a significant percentage of the population would be highly annoyed by new noise. The level of impact at any specific site can be established by comparing the predicted project noise level at the site to the existing noise level at the site. The FTA noise impact criteria for all three land use categories are shown in Figure 4.4-2: FTA Noise Impact Criteria for Transit Projects.

Table 4.4-1: FTA Land Use Categories and Noise Metrics

Land use Category	Noise Metric	Description
1	$L_{eq}(h)$	Tracts of land set aside for serenity and quiet, such as outdoor amphitheaters, concert pavilions, and historic landmarks.
2	L_{dn}	Buildings used for sleeping such as residences, hospitals, hotels, and other areas where nighttime sensitivity to noise is of utmost importance.
3	$L_{eq}(h)$	Institutional land uses with primarily daytime and evening uses including schools, libraries, churches, museums, cemeteries, historic sites, and parks, and certain recreational facilities used for study or meditation.

Source: *Transit Noise and Vibration Impact Assessment - Final Report*, FTA, Washington, D.C., April 1995.

4.4.3 Noise Modeling Methodology and Assumptions

A detailed description of the modeling methodologies and the types of noise sources included in the modeling prediction are included in the following sub-sections.

MODELING METHODOLOGY

A description of the FTA modeling methodologies for operations is included in the following sub-sections.

OPERATIONS

The impact assessment from future transit noise sources along the project corridor was determined according to the FTA guidelines and includes a screening procedure, general assessment, and detailed analysis, as described below:

- Screening Procedure – Identifies existing noise-sensitive land uses along the proposed project corridor and whether or not impact is likely. Further analysis is required if noise-sensitive receptors fall within FTA "screening" distances for various sources.
- General Assessment – Estimates the severity of noise impacts in the Study Area selected during the Screening Procedure analysis. When detailed project data of existing background noise levels are not available, conservative assumptions are used to identify the noise levels at which potential impact could result.
- Detailed Analysis – Quantifies impacts through an in-depth analysis that includes ambient noise monitoring and a delineation of site-specific impacts and mitigation measures for each of the proposed project alternatives.

The Screening Procedure considered a screening distance of 1,000-feet to determine the number, location, and land use types of noise-sensitive receptors along the project corridor.

Because precise alignment and operations data were available, a Detailed Analysis was conducted to quantify the overall noise level at receptors identified during the screening procedure. The noise prediction modeling included all new sources of noise proposed along the project corridor, including LRT train passbys, rail auxiliary equipment at stations, BRT passbys, and BRT idle at stations. Operations data were adjusted based on the existing topography, such as acoustically hard or soft ground, and terrain cuts. Project noise levels from facilities, such as rail yards and the BRT maintenance facility, were predicted using the FTA General Assessment guidelines.

Based on the screening distances shown in Table 4.4-2: FTA Screening Distances for Noise Assessments, over 3,600 receptor locations were identified along the project corridor and included in the modeling analysis. These receptor locations include single- and multi-family residences, hotels, schools, churches, commercial offices, parks, and historic resources.

Project noise levels were described for the two build alternatives: The University Avenue Busway/BRT Alternative operating on a dedicated right-of-way along the median of University Avenue, except in the downtown areas of Minneapolis and St. Paul where BRT buses run along existing roadways in mixed traffic; and the University Avenue LRT Alternative operating on a dedicated right-of-way along the median of University Avenue for the entire length of the corridor. The BRT Alignment would include a total of 25 passenger stations, while the LRT Alignment would include a total of 21 passenger stations.

Table 4.4-2: FTA Screening Distances for Noise Assessments

Project Type	Description	Screening Distance (feet)	
		Unobstructed	Intervening Buildings
Fixed Guideway System	Rail Transit Guideway	700	350
	Rail Transit Station	200	100
	Rail Yard	2,000	1,000
Bus Systems	Busway	500	250
	Bus Storage & Maintenance Facilities	1,000	500

LRT PASSBYS

Bombardier is providing the LRT vehicles for the Hiawatha Corridor and similar vehicles proposed for the Central Corridor. These vehicles consist of 94-foot electrically powered railcars that operate on continuously welded rail tracks. Adjustments to the predicted noise levels for each passby included the following:

- Track type: at-grade (ballast) vs. aerial (concrete slab);
- Train speed
- Consist size and
- Period volumes

Reference data, such as L_{max} and SEL noise levels and average acoustical source height, are shown in Table 4.4-3: Summary of Noise Source Reference Data, for LRT passby noise sources.

Table 4.4-3: Summary of Noise Source Reference Data

Noise Source		Duration	Height	Noise Level (dBA)	
Name	Description	(seconds)	(feet)	L_{max}	SEL
LRT	Train passbys	--[1/]	2	80	82
Auxiliary Equipment	Stations	30	10	65	101
BRT	Bus passbys	--	8	85	88
BRT Idle	Stations	20	8	74	110
Rail Yard/Layover Facility	Rail Yard	--	2	82	118
BRT Maintenance Yard	BRT Facility	--	8	75	111
Wheel Squeal-LRT	Curves with Radius <82 ft	4	0	100	136

[1/] Not applicable. Passby and facility noise prediction equations do not require a duration time.

Note: All noise levels are based on a reference distance of 50-feet and a speed of 50 mph (for mobile sources).

BRT PASSBYS

The BRT vehicles consist of 60-foot hybrid electric articulated buses with three axles that would travel primarily on the dedicated BRT right-of-way along the Central Corridor. Adjustments to the predicted noise levels for each passby included BRT travel speed and period volumes. A maximum speed of 30 mph was used everywhere along the Project Corridor. Reference data, such as L_{max} and SEL noise levels and average acoustical source height, are shown in Table 4.4-6 for BRT passby noise sources. Default FTA reference noise data for commuter buses, including noise level and source height, were used for the proposed articulated BRT vehicles.

STATIONARY SOURCES

In addition to LRT and BRT passbys, several stationary sources were also included in the modeling prediction analysis including:

- LRT auxiliary equipment at stations
- BRT vehicle idling at passenger stations
- LRT wheel squeal along tight-radius curves

All reference data, such as L_{max} and SEL source noise levels and average acoustical source height, are shown in Table 4.4-3 for each of the stationary sources.

WHEEL SQUEAL

Wheel squeal occurs from train passbys in tight-radius curves. Based on typical manufacturer's specifications, wheel squeal from these vehicles is not expected to occur at curves with a radius above 82-feet.

AUXILIARY EQUIPMENT

LRT auxiliary equipment, such as rooftop heating and ventilation units, were also included in the noise modeling analysis at stations. Although the auxiliary equipment is included in the cumulative LRT passby noise level, it is the dominant train noise source when the LRT trains are stopped at the station and is, therefore, modeled separately. As shown in Table 4.4-3, an average delay time in the station of 20-seconds and an LRT rooftop source height of 10-feet was used to predict project noise levels from auxiliary equipment.

BUS IDLING

Idling noise from BRT vehicles near stations were also included in the modeling prediction analysis. Although each source type has different reference idling noise levels, as shown in Table 4.4-3, overall idling noise predicted from BRT buses is based on average idling times of 20-seconds with an average acoustical source height of 10-feet. This average acoustical height is based on a rooftop exhaust location.

FACILITIES

In addition to the LRT and BRT operations, several ancillary facilities were also included in the modeling prediction analysis including:

- Rail Yards
- BRT Maintenance Facility

All reference data, such as L_{max} and SEL source noise levels and average acoustical source height, are shown in Table 4.4-3 for each of the facility noise sources.
Event noise levels from each facility noise source were predicted at each of the identified receptor locations along the project corridor using the FTA methodology.

RAIL YARDS

Noise from activities at rail yards includes train movements through switches (which is normally associated with the clickety-clack sounds), and maintenance work. Overall yard noise was predicted at nearby receptor locations from the following facilities:

- LRT Maintenance Facility on Franklin Avenue (Minneapolis)
- LRT layover facility near Gillette factory (St. Paul)

As shown in Table 4.4-3, rail yard noise levels from general train activities are based on the FTA reference levels.

BRT MAINTENANCE FACILITY

Noise from activities at the BRT Maintenance Facility on Snelling Avenue was also predicted at nearby receptors based on default FTA operations. The BRT Maintenance Facility was included under the BRT Alternative only. As shown in Table 4.4-3, BRT Maintenance Facility noise from general bus servicing and cleaning activities is based on the FTA reference levels.

24-HOUR L_{DN} NOISE LEVEL

At residential receptors identified along the project corridor, including residences and hotels, the 24-hour L_{dn} noise level was used to assess impact against the FTA impact criteria. Using Equation 1, average hourly L_{eq} noise levels during the daytime (from 7 AM to 10 PM) and the nighttime (from 10 PM to 7 AM) periods were used to develop an overall 24-hour L_{dn} noise level.

$$Ldn_{50} = 10\log\left[15\times10^{\left(\frac{LeqD_{50}}{10}\right)} + 9\times10^{\left(\frac{LeqN_{50}+10}{10}\right)}\right] - 10\log(24) \qquad \text{[Eq. 1]}$$

Where:

- L_{dn50} = 24-hour L_{dn} noise level at 50-feet (in dBA)
- $L_{eq}D_{50}$ = average daytime hourly $L_{eq}(h)$ noise level at 50-feet between 7 AM and 10 PM (in dBA)
- $L_{eq}N_{50}$ = average nighttime hourly $L_{eq}(h)$ noise level at 50-feet with 10-dBA penalty applied for nighttime events between 10 PM and 7 AM (in dBA)
- -10log(24) = L_{dn} adjustment factor based on the number of hours in a day (in dBA)

ATTENUATION AND SHIELDING EFFECTS

In areas along the proposed project corridor with intervening structures, such as buildings, or terrain features that affect the noise propagation path between the transit source and receptor, noise attenuation was determined on a receptor-by-receptor basis. The following shielding and attenuation factors were included in the modeling analysis:

- Ground attenuation effects
- Terrain cut shielding effects
- Building shielding effects
- Atmospheric divergence or distance attenuation

All methodologies are based on the FTA modeling guidelines.

4.4.4 Existing Noise Conditions

Existing noise along the proposed project corridor was measured to characterize ambient background levels in the community. The scope and the results of the noise measurement program are described in the following subsections.

BACKGROUND AMBIENT NOISE LEVELS

In accordance with FTA noise guidelines, a noise-monitoring program was conducted along the Study Area from downtown Minneapolis to downtown St. Paul along University Avenue to (1) establish the existing ambient background levels within the proposed project area and (2) develop project criteria noise limits.

As shown in Figure 4.4-3: Community Noise Monitoring Locations along the Central Corridor, noise measurements were obtained at 10 receptor locations along the Central Corridor. Three measurements were obtained for a 24-hour period, and seven measurements were conducted for the peak, off-peak and nighttime periods. The results were used to establish baseline noise levels for both residential and non-residential receptors. The existing noise environment was characterized according to the FTA land use categories shown in Table 4.4-1.

Existing land uses along the Central Corridor are exposed to a variety of noise sources ranging from vehicular traffic to cross streets and arterials. Noise measurements were conducted at noise-sensitive locations along the corridor. The monitoring locations shown in Figure 4.4-3 were selected to be representative of the types of neighborhoods and land uses found along the corridor. The results of the community noise-monitoring program were used to establish the existing background noise levels and to develop the allowable project criteria using the FTA guidelines. The noise-monitoring program was conducted in November 2001 at 10 receptor locations to establish existing peak-hour L_{eq} noise levels at non-residential locations and 24-hour L_{dn} noise levels at residences. The results of the noise-monitoring program, including measurement date, time, and noise levels, are summarized in Table 4.4-4: Summary of Noise Measurement Program Along the Central Corridor, for each of the 10 discrete receptors.

ESTIMATE 24-HOUR L_{DN} NOISE LEVELS FROM CONTINUOUS MEASUREMENTS

At several residences, continuous 24-hour noise measurements were conducted to establish the existing background L_{dn} noise levels. At each location, 24 hourly L_{eq} noise measurements were collected during one continuous 24-hour period. To compute the L_{dn} noise level, the hourly L_{eq} noise levels were summed logarithmically, with a 10-dBA penalty applied to all measurements conducted between 10 PM and 7 AM. The results of these calculations are summarized Table 4.4-4.

ESTIMATE 24-HOUR L_{DN} NOISE LEVELS FROM SHORT-TERM MEASUREMENTS

At those receptor locations where 24-hour continuous noise measurements were not collected, short-term noise measurements were conducted during various periods of the day as a substitute. Following the FTA guidelines, short-term noise measurements were conducted during the each of the following periods:

- AM or PM peak-hour period (7-9 AM or 4-6 PM)
- Midday or off-peak period (9 AM-4 PM)
- Late night period (12-4 AM).

To account for the reduced measurement period, a 2-dBA penalty is applied to all measured L_{eq} noise levels resulting in a slightly conservative estimate of the actual 24-hour L_{dn} noise level.

The final results of the noise-monitoring program are summarized in Table 4.4-5: Summary of Existing Ambient Noise Levels (dBA). These finalized L_{eq} and L_{dn} levels were used in the modeling analysis to establish background noise levels at all other identified receptors along the proposed project corridor. Where noise measurements were not conducted, an equivalent background level was estimated based on its similarity to one of the 10 discrete receptors. This equivalencing evaluated land use, location to cross streets or other major ambient noise sources, and vicinity to the ten discrete receptors.

An existing peak-hour equivalent noise level, or $L_{eq}(h)$, measured at the State Capitol was 68 dBA. Similarly, 24-hour noise measurements conducted to establish residential day-night noise levels, or L_{dn}, ranged from 53 dBA at location N6 (a residence along Lynhurst Avenue) to 68 dBA at N1 (a senior home in downtown Minneapolis). The measured noise levels are fairly typical for both urban areas and community developments along highway corridors.

Table 4.4-4: Summary of Noise Measurement Program Along the Central Corridor

Noise Measurement Location		FTA L.U. Cat.	Noise Measurement Period											
			Peak-Hour			Off-Peak (9 AM – 4 PM)			Latenight (12-4 AM)			24-hour L_{dn}		
No.	Description		Date	Time	L_{eq}[1]	Date	Time	L_{eq}[1]	Date	Time	L_{eq}[1]	Date	Time	L_{dn}[1]
N1	Residence, Senior Home, Minneapolis, N Fourth St. and Hennepin Ave.	2	11/14/01	13:03	69.2	11/13/01	14:51	68.5	11/14/01	00:19	60.7	--[2]	--	67.5
N2	Hospital, Minneapolis, Hennepin County Medical Center, Sixth St.	2	11/12/01	17:40	61.9	11/13/01	14:12	64.1	11/14/01	00:53	57.9	--	--	63.8
N3	Hospital, Campus Area, Boynton Health Service, Church & Wash.	2	11/09/01	10:05	72.8	11/12/01	15:18	69.7	11/14/01	01:37	58.8	--	--	68.0
N4	Residence, University Area, 79 SE Clarence Ave.	2	11/14/01	07:26	56.9	--	--	--	--	--	--	11/14/01	10:26	53.9
N5	Residence, University Area, 808 Seal St. near Raymond Ave.	2	11/14/01	13:27	61.7	11/15/01	10:57	61.1	11/14/01	15:32	50.0	--	--	58.8
N6	Residence, University Area, 499 Lynhurst Ave.	2	11/14/01	13:50	53.9	11/14/01	12:40	55.2	11/14/01	15:08	45.1	--	--	53.0
N7	Residence, University Area, 1414 Sherbourne Ave.	2	11/14/01	07:31	59.3	--	--	--	--	--	--	11/14/01	11:31	61.0
N8	Residence, University Area, 386 Aurora Ave.	2	11/15/01	07:22	62.6	--	--	--	--	--	--	11/15/01	12:22	64.7
N9	Institution, St. Paul, State Capitol	3	11/09/01	16:07	67.5	--	--	--	--	--	--	--	--	51.7
N10	Residence, St. Paul, 4th St. and Robert St.	2	11/09/01	13:00	67.5	11/13/01	05:30	67.4	11/14/01	14:22	57.9	--	--	65.6

1. All L_{eq} and L_{dn} noise levels are reported in dBAs.
2. '--' = Not applicable. No noise measurements were conducted during the selected period.

Table 4.4-5: Summary of Existing Ambient Noise Levels (dBA)

Receptor		Area	Type[1/]	Land use Cat.	Noise Level	
No.	Description and Location			FTA	L_{eq}	L_{dn}
N1	Senior Home, N Fourth St. and Hennepin Ave.	Minneapolis	Res.	2	--	68
N2	Hennepin County Medical Center, Sixth St.	Minneapolis	Oth.	2	--	64
N3	Boynton Health Service, Church & Washington	Campus	Oth.	2	--	68
N4	Residence, 79 SE Clarence Ave.	University	Res.	2	--	54
N5	Residence, 808 Seal St. near Raymond Ave.	University	Res.	2	--	59
N6	Residence, 499 Lynhurst Ave.	University	Res.	2	--	53
N7	Residence, 1414 Sherbourne Ave.	University	Res.	2	--	61
N8	Residence, 386 Aurora Ave.	University	Res.	2	--	65
N9	Institution, State Capitol	St. Paul	NR	3	68	--
N10	Residence, 4th St. and Robert St.	St. Paul	Res.	2	--	66

[1/] Receptor types include residential (Res.), non-residential (NR), and other receptor types (e.g., hotels and parks).

4.4.5 Long Term Noise Effects

A noise assessment was completed to determine the potential noise related impacts at various sensitive receptor locations along the Central Corridor. The noise levels predicted at the discrete receptors for each of the build alternatives were determined using the FTA guidelines and methodologies. These levels were then compared to the FTA criteria. Corridor-wide impacts from operations were then evaluated at noise-sensitive receptors within approximately 1,000-feet of the proposed corridor alignments.

The results of the noise impact assessment for each of the proposed project alternatives are described in the following subsections.

BASELINE ALTERNATIVE

In accordance with FTA guidelines, noise impacts from the future build alternatives are not compared to the Baseline Alternative to determine impact. Instead, the FTA analysis methodology establishes project criteria noise limits based on existing measured noise levels along the proposed project corridor. Exceedances of the FTA noise criteria limits under the build alternatives are considered impacts of the project. Therefore, FTA guidelines do not require a noise assessment for the future Baseline Alternative.

UNIVERSITY AVENUE LRT ALTERNATIVE

The LRT Alternative would operate along a dedicated right-of-way running in the median along the Central Corridor.

Federal Criteria

The peak-hour L_{eq} noise level, shown in Table 4.4-9: FTA Noise Impact Summary at Discrete Receptors from Transit Operations (dBA), is predicted to be 45 dBA at R9 (State Capitol in St. Paul). The peak hour L_{eq}(h) noise level is not expected to exceed the FTA Land Use Category 3 *impact* or *severe impact* criteria at the selected discrete receptor.

Table 4.4-6: FTA Noise Impact Summary at Discrete Receptors from Transit Operations (dBA)

Receptor		FTA Land use Category	Existing BKGD Level	Alternative		Impact Criteria	
No.	Description			LRT	BRT	IMP	SEV
R1	Senior Home, N 4th St. and Hennepin Ave.	2	68 L_{dn}	53	67	63	68
R2	Hennepin County Medical Center, 6th St.	2	64 L_{dn}	39	40	60	66
R3	Hospital, Boynton Health Service	2	68 L_{dn}	27	63	63	68
R4	Residence, 79 SE Clarence Ave.	2	54 L_{dn}	41	48	55	61
R5	Residence, 808 Seal St. near Raymond Ave.	2	59 L_{dn}	37	44	57	63
R6	Residence, 499 Lynhurst Ave.	2	53 L_{dn}	46	53	54	61
R7	Residence, 1414 Sherbourne Ave.	2	61 L_{dn}	50	56	58	64
R8	Residence, 386 Aurora Ave.	2	65 L_{dn}	47	53	61	66
R9	Institution, State Capitol	3	68 L_{eq}	45	54	68	73
R10	Residence, 4th St. and Robert St.	2	66 L_{dn}	50	59	61	67

Note: Assessment of impact is determined as follows: No Impact and Impact

At residential receptors (Category 2), 24-hour L_{dn} levels from LRT operations are predicted to range from 27 dBA at R3 (Boynton Health Service in Campus) to 53 dBA at R1 (Senior Home on Hennepin Avenue in Minneapolis). As shown in Table 4.4-6, none of the predicted L_{dn} levels are expected to exceed the FTA Land Use Category 2 *impact* or *severe impact* criteria at the discrete receptor locations under the LRT Alternative.

As shown in Table 4.4-7: Summary of FTA Noise Impact Counts, corridor-wide project noise levels under the University Avenue LRT Alternative are predicted to exceed the FTA Category 2 Land Use *impact* criteria at 11 locations. Project noise levels are not predicted to exceed the *severe impact* criteria anywhere along the proposed project corridor. Similarly, project noise levels are also predicted to exceed the Category 3 Land Use *impact* criteria at one additional location under the LRT Alternative. No exceedances of the FTA Category 1 Land Use criteria are predicted under the LRT Alternative. The impact assessment includes impacts at structures only. The receptor locations, where exceedance of the FTA *impact* and *severe impact* criteria is predicted, are shown in Figure 4.4-3.

Table 4.4-7: Summary of FTA Noise Impact Counts

Corridor Section	Impact Criteria Category	Alternative			
		BRT		LRT	
		Category 2	Category 3	Category 2	Category 3
Downtown Minneapolis	Impact	1	0	0	0
	Severe Impact	0	0	0	0
	Sum	1	0	0	0
Campus	Impact	5	1	0	1
	Severe Impact	1	0	0	0
	Sum	6	1	0	1
University Avenue	Impact	86	18	11	0
	Severe Impact	10	0	0	0
	Sum	96	18	11	0
Downtown St. Paul	Impact	2	0	0	0
	Severe Impact	0	0	0	0
	Sum	2	0	0	0
Totals	Impact	94	19	11	1
	Severe Impact	11	0	0	0
	Sum	105	19	11	1

Note: FTA land use categories include residential (Category 2) and institutional (Category 3) receptors.

UNIVERSITY AVENUE BUSWAY/BRT ALTERNATIVE

Under the BRT Alternative, transit operations along the Central Corridor would consist of low-floor, 60-foot articulated transit buses.

Federal Criteria

As shown in Table 4.4-7, the peak-hour L_{eq} noise level from BRT operations along the Central Corridor is predicted to be 54 dBA at R9 (State Capitol in St. Paul). The peak hour L_{eq}(h) noise level is not expected to exceed the FTA Land Use Category 3 *impact* or *severe impact* criteria at the selected discrete receptor under the BRT Alternative.

At residential receptors (Category 2), 24-hour L_{dn} levels from BRT operations are predicted to range from 40 dBA at R2 (Hennepin County Medical Center) to 67 dBA at R1 (Senior Home on Hennepin Avenue in Minneapolis). As shown in Table 4.4-6, except for receptor R1, none of the predicted L_{dn} levels are expected to exceed the FTA Land Use Category 2 *impact* or *severe impact* criteria at the selected receptor locations under the BRT Alternative. The predicted L_{dn} noise level of 67 dBA at receptor R1 is, however, predicted to exceed the FTA *impact* criterion of 63 dBA under the BRT Alternative.

As shown in Table 4.4-7, corridor-wide project noise levels are predicted to exceed the FTA Category 2 land Use *impact* criteria at 94 locations and the *severe impact* criteria at an additional 11 locations under the BRT Alternative. Similarly, exceedances of the FTA Category 3 Land Use *impact* criteria are also predicted at 19 additional locations. No exceedances of the FTA Category 1 Land Use criteria are predicted under the BRT Alternative. The corridor-wide impact assessment evaluated impacts at noise-sensitive locations, such as residences, offices, and parks. The number of impacted Category 2 receptors includes buildings and structures such as single- and multi-family dwellings. The receptor locations, where exceedances of the FTA *impact* and *severe impact* criteria under the BRT Alternative are predicted to occur, are shown in Figure 4.4-1.

4.4.6 Noise Mitigation

Mitigation measures to reduce the onset of noise impacts along the Central Corridor from BRT and LRT operations are described in the following subsections.

UNIVERSITY AVENUE LRT ALTERNATIVE

The following recommended mitigation measures are specific to the LRT Alternative.

LRT Operations

Noise impacts due to LRT train passbys were predicted at several locations under the LRT Alternative. As a result of the noise impact assessment, noise dampening measures are recommended at the following approximate locations based on the evaluation criteria as shown in Table 4.4-8: Recommended Noise Mitigation Along the LRT Alignment.

Table 4.4-8: Recommended Noise Mitigation Along the LRT Alignment

Sta. No.		Corridor Location	Mitigation Description
From	To		Criteria
Westbound Side of LRT Corridor			
2324+00	2325+00	University	FTA
2326+00	2333+00	University	FTA
Eastbound Side of LRT Corridor			
2311+00	2313+00	Campus	FTA
2319+00	2321+00	University	FTA
2409+00	2412+00	University	FTA
2435+00	2437+00	University	FTA
2438+00	2441+00	University	FTA

In addition to noise mitigation measures, several additional mitigation measures should be investigated including:

- Operational limitations to reduce the overall cumulative noise (such as peak-hour L_{eq} and 24-hour L_{dn} noise levels). Such operational limitations may include:
  - Travel speed reductions along particularly noise-sensitive areas
  - Nighttime restrictions to minimize the impacts at residential and other FTA Land Use Category 2 receptors during the quietest period of the day
- Building insulation is effective in reducing transit noise inside the affected structure. Outdoor activities, however, would not benefit from sound insulation.

UNIVERSITY AVENUE BUSWAY/BRT ALTERNATIVE

The following recommended mitigation measures are specific to the BRT Alternative.

BRT Operations

Although noise levels from on-road vehicles are regulated by federal and State agencies, several mitigation measures are recommended to minimize or eliminate noise impacts predicted along the proposed project corridor. These mitigation measures may include:

- Operational limitations to reduce the overall cumulative noise (such as peak-hour L_{eq} and 24-hour L_{dn} noise levels). Such operational limitations may include:
  - Travel speed reductions along particularly noise-sensitive areas
  - Nighttime restrictions to minimize the impacts at residential and other FTA Land Use Category 2 receptors during the quietest period of the day
  - Idle restrictions at stations closest to nearby noise-sensitive receptors.
- After-market noise silencers applied to the inside of the BRT engine compartment. According to the FTA guidance, noise silencers would reduce overall engine noise during both passbys and during idle at stations 6 to 10 dBA. Noise silencers for BRT engines would not, however, reduce rooftop exhaust noise
- Although default FTA reference noise levels were used in the absence of more accurate data, vehicle-specific noise levels from the selected BRT manufacturer should be investigated further for more precise refinement of the modeling impact assessment

Due to the elevated average source height of the BRT vehicles (i.e., 10-foot exhaust height) and the numerous cross streets, noise barriers are not recommended to mitigate the predicted impacts. Based on the location of predicted impacts and the need for access from the numerous cross streets, noise barriers are not expected to be feasible. Noise generated from BRT operation is expected to be higher than that from LRT.

4.4.7 Vibration

This section introduces some basic ground-borne vibration and noise concepts including the prediction methodologies and modeling assumptions, the results of the existing source vibration measurement program, and the evaluation of impacts along the proposed project corridor.

4.4.8 Human Perception of Vibration

The characteristics and properties used to describe ground-borne vibration and noise are explained in the following subsections.

DESCRIBING VIBRATION

Ground-borne vibration associated with vehicle movements is usually the result of uneven interactions between the wheel and the road or rail surfaces. Examples of such interactions (and subsequent vibrations) include train wheels over a jointed rail, an untrue railcar wheel with "flats", and motor vehicle wheels hitting a pothole or even a manhole cover.

Unlike noise, which travels in air, transit vibration typically travels along the surface of the ground. Depending on the geological properties of the surrounding ground and the type of building structure exposed to transit vibration, vibration propagation may be more or less efficient. Buildings with a solid foundation set in bedrock are "coupled" more efficiently to the surrounding ground and experience relatively higher vibration levels than those buildings located in sandier soil.

Similarly, ground-borne noise results from vibrating room surfaces located near a heavily traveled transit corridor, such as a subway line. As a result, annoyance due to the "rumbling" sound from ground-borne noise is only evaluated indoors and is described using dBA.

DESCRIPTION OF VIBRATION LEVELS

Vibration induced by vehicle passbys can generally be discussed in terms of displacement, velocity, or acceleration. However, human responses and responses by monitoring instruments and other objects are more accurately described with velocity. Therefore, the vibration velocity level is chosen to assess vibration impacts.

To more accurately describe the human response to vibration, the average vibration amplitude called the root mean square (RMS) amplitude, is used to assess impacts. The RMS velocity is expressed in inches per second (ips) or vibration decibels (VdB). Vibration levels are referenced to 1 micro inches per second (μips).

To evaluate the potential for damage to buildings, the peak particle velocity (PPV) is also used to characterize the vibration. Typically expressed in units of ips, PPV represents the maximum instantaneous vibration velocity observed during an event. Typical ground-borne vibration levels from transit and other common sources are shown in Figure 4.4-4: Typical Ground-Borne Vibration Levels.

4.4.9 Vibration Evaluation Criteria

As described in the following subsections, the FTA criteria will be used to assess annoyance due to vibration and ground-borne noise from single event transit operations.

OPERATIONAL VIBRATION

The FTA criteria are used to evaluate vibration from single-event transit passbys.

Federal Criteria

The FTA vibration criteria for evaluating ground-borne vibration (and noise) impacts from train passbys at nearby sensitive receptors are shown in Table 4.4-9: FTA Ground-Borne Vibration Impact Criteria for Annoyance (VdB). These vibration criteria are related to ground-borne vibration levels that are expected to result in human annoyance, and are based on RMS velocity levels expressed in VdB relative to 1 μips. The FTA's experience with community response to ground-borne vibration indicates that when there are only a few train events per day, it would

Table 4.4-9: FTA Ground-Borne Vibration Impact Criteria for Annoyance (VdB)

Receptor Land use		RMS Vibration Levels (VdB)		Ground-Borne Noise Levels (dBA)	
Category	**Description**	**Frequent Events**	**Infrequent Events**	**Frequent Events**	**Infrequent Events**
1	Buildings where low vibration is essential for interior operations	65	65	N/A	N/A
2	Residences and buildings where people normally sleep	72	80	35	43
3	Daytime institutional and office use	75	83	40	48
Specific Buildings	TV/Recording Studios/Concert Halls	65	65	25	25
	Auditoriums	72	80	30	38
	Theaters	72	80	35	43

Note: N/A = not applicable. Vibration-sensitive equipment, for example, is not sensitive to ground-borne noise.
Source: *Transit Noise and Vibration Impact Assessment - Final Report*, FTA, Washington, D.C., April 1995.

take higher vibration levels to evoke the same community response that would be expected from more frequent events. This is taken into account in the FTA criteria by distinguishing between projects with 'frequent' and 'infrequent' events, where the 'frequent' events category is defined as more than 70 events per day. The vibration criteria levels shown in Table 4.4-9 are defined in terms of human annoyance for different land use categories such as high sensitivity (Category 1), residential (Category 2), and institutional (Category 3). In general, the vibration threshold of human perceptibility is roughly 65 VdB.

The vibration levels shown in Table 4.4-9 are well below the damage criteria levels of approximately 95 to 100 VdB. It is extremely rare for vibration from train operations to cause any sort of building damage, including minor cosmetic damage.

While vibration criteria are generally used to assess annoyance from transit sources at the exterior facade of receptors, ground-borne noise, or the rumbling sound due to vibrating room surfaces, is typically assessed indoors. In general, the relationship between vibration and ground-borne noise depends on the dominant frequency of the vibration and the acoustical absorption characteristics of the receiving room. Due to the limited data available regarding soil and ground propagation characteristics, average or typical soil conditions were assumed everywhere along the corridor for computing ground-borne noise.

4.4.10 Vibration Modeling Methodology and Assumptions

A description of the modeling methodologies and the types of vibration sources included in the modeling prediction are described in the following sub-sections.

MODELING METHODOLOGY

Using the FTA's General Assessment methodology, vibration levels from LRT train passbys were predicted at receptors along the proposed project corridor. Due to the complexity and cost associated with a Detailed Assessment, the General Assessment approach is fairly conservative. Impacts identified under the General Assessment approach should be investigated further during final design when details of the final track structure are better known.

Over 3,600 receptor locations were identified along the proposed project corridor and included in the modeling analysis. These receptor locations include single- and multi-family residences, hotels, schools, churches, commercial offices, parks, and historic resources.

OPERATIONS

Vibration levels from LRT passbys at sensitive receptors along the proposed project corridor were determined using the FTA guidelines. Although BRT operations are also proposed, rubber-tired vehicles are typically not a major source of vibration annoyance, especially lighter-weight transit buses. Therefore, only railcar passbys along continuously welded rail and rail discontinuities such as switches and crossovers were included in the modeling analysis.

A vibration measurement program was conducted to better determine the extent of ground-borne vibration levels from existing LRT trains as well as to provide insight into the type of soil conditions found along the proposed project corridor. The results of the measurement program are discussed in Section 4.4.11

LRT

Reference vibration levels from LRT passbys at 50 mph are based on the FTA ground-surface propagation curves as shown in Figure 4.4-5: FTA Generalized Ground Surface Vibration Curves. However, this will only be achieved in tunnel operation. Using the 'Rapid Transit' curve, a reference RMS vibration level could be determined at the distance for each identified receptor location. Depending on the receptor location, adjustments for speed and rail discontinuities were also taken into account.

4.4.11 Existing Vibration Conditions

The scope and results of the vibration-monitoring program are described in the following section.

TRANSIT SOURCE LEVELS

A vibration-monitoring program was conducted along the Study Area from downtown Minneapolis to downtown St. Paul along University Avenue to better define the existing vibration characteristics. As with noise, existing land uses along the Central Corridor are exposed to a variety of vibration sources ranging from bus and truck passbys along roadways to freight and commuter rail passbys to ongoing construction activity. As shown in Figure 4.4-3, vibration measurements were obtained at the same 10-receptor locations included in the noise-monitoring program. The monitoring locations shown in Figure 4.4-3 were selected to be representative of the types of neighborhoods and land uses found along the corridor. The results of the community vibration-monitoring program were used to establish the existing background noise levels and to adjust the ground propagation characteristics of the FTA default ground-surface vibration curve. The results of the vibration-monitoring program, including measurement date and observed ambient vibration levels, are summarized in Table 4.4-10: Summary of Vibration Measurement Program Along the Central Corridor (in VdB), for each of the 10 discrete receptors.

The results of the vibration measurement program suggest that the proposed project corridor exhibits ground propagation characteristics typical for urban transit corridors. Therefore, the default FTA ground-surface vibration curve was used to predict vibration levels from transit operations at nearby sensitive receptors without any adjustments.

Table 4.4-10: Summary of Vibration Measurement Program Along the Central Corridor (in VdB)

Receptor					Measurement Results[2/]		
No.	Description and Location	Area	Type[1/]	FTA Cat.	Date	Avg.	Peak
N1	Senior Home, N Fourth St. and Hennepin Ave.	Minneapolis	Res.	2	11/06/01	63	72
N2	Hennepin County Medical Center, Sixth St.	Minneapolis	Oth.	2	11/06/01	54	63
N3	Boynton Health Service, Church & Washington	Campus	Oth.	2	11/08/01	56	64
N4	Residence, 79 SE Clarence Ave.	University	Res.	2	11/06/01	58	65
N5	Residence, 808 Seal St. near Raymond Ave.	University	Res.	2	11/06/01	55	58
N6	Residence, 499 Lynhurst Ave.	University	Res.	2	11/06/01	54	61
N7	Residence, 1414 Sherbourne Ave.	University	Res.	2	11/06/01	54	61
N8	Residence, 386 Aurora Ave.	University	Res.	2	11/06/01	55	62
N9	Institution, State Capitol	St. Paul	NR	3	11/07/01	52	59
N10	Residence, 4th St. and Robert St.	St. Paul	Res.	2	11/09/01	48	54

[1/] Receptor types include residential (Res.), non-residential (NR), and other receptor types (e.g., hotels and parks).
[2/] Average ambient vibration levels (Avg.) and maximum observed levels (Peak) are reported in VdB re 1μips.

4.4.12 Long Term Vibration Effects

Vibration impacts from LRT vehicles were evaluated at discrete receptors using the FTA criteria based on maximum single-event passbys as described in the following sections. Unlike the cumulative noise criteria, vibration criteria are evaluated based on single-event passbys. The results of the impact assessment are described in the following subsections.

BASELINE ALTERNATIVE

In accordance with FTA guidelines, vibration impacts are only assessed from new proposed vibration sources such as LRT passbys. Under the Baseline Alternative, neither the BRT nor the LRT would be in service along the Central Corridor. Therefore, because no new sources of vibration are expected under the Baseline Alternative, a vibration impact assessment is not required.

UNIVERSITY AVENUE LRT ALTERNATIVE

The results of the vibration and ground-borne noise assessment are described in the following sub-sections.

Federal Criteria

Under the LRT Alternative, new continuously welded rail is proposed at all sections of the alignment. Predicted vibration levels are expected to be well below the FTA impact criteria for frequent events at most of the FTA land use Category 1, 2, or 3 receptors identified along the proposed project corridor. For example, as shown in Table 4.4-11: Vibration and Ground-borne Noise Impact Summary at Discrete Receptors (VdB), predicted vibration levels from LRT passbys are expected to range from below background levels at R2 (Hennepin County Medical Center in Minneapolis) and R5 (Residence at 808 Seal Street in University) to 69 VdB at R3 (Boynton Health Service Center in Campus). These levels are below the FTA impact criterion of 72 VdB for Category 2 land uses.

Table 4.4-11: Vibration and Ground-borne Noise Impact Summary at Discrete Receptors (VdB)

Receptor		FTA Cat.	Dist. To Align.[1/]	BRT		LRT		FTA	
No.	Description			VIB	GB-NZ	VIB	GB-NZ	VIB	GB-NZ
R1	Senior Home, N 4th St. and Hennepin	2	81	--[2/]	--	65	30	72	35
R2	Hennepin County Medical Center	2	586	--	--	0	0	72	35
R3	Hospital, Boynton Health Service	2	81	--	--	69	34	72	35
R4	Residence, 79 SE Clarence Ave.	2	436	--	--	31	0	72	35
R5	Residence, 808 Seal St.	2	646	--	--	0	0	72	35
R6	Residence, 499 Lynhurst Ave.	2	418	--	--	36	1	72	35
R7	Residence, 1414 Sherbourne Ave.	2	259	--	--	55	20	72	35
R8	Residence, 386 Aurora Ave.	2	382	--	--	43	8	72	35
R9	Institution, State Capitol	3	137	--	--	56	21	75	40
R10	Residence, 4th St. and Robert St.	2	53	--	--	65	30	72	35

[1/] Closest distance between receptor and the proposed Build Alternative alignments.
[2/] '--' = below detection. Vibration (VIB) and Ground-Borne Noise (GB-NZ) levels from BRT passbys are expected to be well below the ambient background.

Similarly, maximum ground-borne noise levels due to LRT passbys, as shown in Table 4.4-11, are expected to range from less than background levels at several receptors including R2, R4, R5, R6, and R8 to 34 dBA at R3 (Boynton Health Service Center in Campus). No Exceedances of the FTA land use Category 1, 2, and 3 ground-borne noise impact criteria are predicted at any of the discrete receptor locations under the LRT Alternative.

Corridor wide, exceedances of the FTA vibration impact criteria are predicted to occur at one FTA Category 2 receptor and 10 Category 3 receptors under the LRT Alternative, as shown in Table 4.4-12: Summary of Vibration Impact Counts – Corridor Wide. Similarly, exceedances of the FTA ground-borne noise impact criteria are predicted to occur at two FTA Category 2 receptors and 10 Category 3 receptors under the LRT Alternative.

Table 4.4-12: Summary of Vibration Impact Counts – Corridor Wide

Corridor Section	Impact Criteria Type	Alternative			
		BRT		LRT	
		Category 2	Category 3	Category 2	Category 3
Downtown Minneapolis	RMS Vibration	NA	NA	0	1
	Ground-Borne Noise	NA	NA	0	1
	Sum	NA	NA	0	2
Campus	RMS Vibration	NA	NA	0	4
	Ground-Borne Noise	NA	NA	0	4
	Sum	NA	NA	0	8
University Avenue	RMS Vibration	NA	NA	1	5
	Ground-Borne Noise	NA	NA	2	5
	Sum	NA	NA	3	10
Downtown St. Paul	RMS Vibration	NA	NA	0	0
	Ground-Borne Noise	NA	NA	0	0
	Sum	NA	NA	0	0
Totals	RMS Vibration	NA	NA	1	10
	Ground-Borne Noise	NA	NA	2	10
	Sum	NA	NA	3	20

Note: NA means not applicable. A vibration impact assessment for the BRT Alternative was not determined.

Historic Resources

As shown in Table 4.4-13: FTA Vibration Impact Summary From Operations at Historic Resources, vibration levels from LRT passbys near historic resources are predicted to range from below ambient levels at several locations to 73 VdB at H12 (Union Station at Sibley Street in St. Paul). These levels are all well below the FTA land use Category 1, 2, and 3 impact criteria. Similarly, ground-borne noise levels at historic resources are also not predicted to exceed the FTA land use Categories 1, 2, or 3 impact criteria under the LRT Alternative. All of the predicted vibration levels are well below the threshold for minor cosmetic damage of 95 VdB.

Table 4.4-13: FTA Vibration Impact Summary From Operations at Historic Resources

Historic Resource		FTA Cat.	Dist. to Align.[1/]	BRT	LRT			
No.	Description				RMS Vibration[2/]	GB-Noise[3/]	FTA VIB[2/]	FTA GB-NZ[3/]
H1	United Way of St. Paul Charitable Institute, 172 4th Street (St. Paul)	3	53	N/A[4/]	65	30	75	40
H2	Union Depot Commercial Building, 214 4th Street (St. Paul)	3	157	N/A	64	29	75	40
H3	Commercial Building, 4th Street (St. Paul)	3	36	N/A	68	33	75	40
H4	Sibley Park Operating Association, 400 Sibley Street (St. Paul)	3	746	N/A	BD[5/]	BD	75	40
H5	Galtier Plaza Apartments, 198 6th Street (St. Paul)	2	407	N/A	33	BD	72	35
H6	US Postal Service, 180 Kellogg Blvd (St. Paul)	3	726	N/A	BD	BD	75	40
H7	US Postal Service, 162 Kellogg Blvd (St. Paul)	3	404	N/A	34	BD	75	40
H8	L A Venaglia Commercial Building, 241 Kellogg Blvd (St. Paul)	3	285	N/A	58	23	75	40
H9	Lowertown Lofts Cooperative Residence, 255 Kellogg Blvd (St. Paul)	2	245	N/A	60	25	72	35
H10	Army Corps Center Commercial Bldg, 333 Sibley Street (St. Paul)	3	34	N/A	68	33	75	40
H11	Apartment Building, 262 4th Street (St. Paul)	2	227	N/A	60	25	72	35
H12	Union Station, 352 Sibley Street (St. Paul)	3	61	N/A	73	38	75	40
H13	Commercial Building, 4th Street (St. Paul)	3	141	N/A	64	29	75	40
H14	Port of Authority of St. Paul Municipal Bldg, 230 5th Street (St. Paul)	3	208	N/A	63	28	75	40
H15	James Steele Construction Company, 352 Wacouta Street (St. Paul)	3	222	N/A	61	26	75	40
H16	PMA Limited Partnership Commercial Bldg, 281 Kellogg Blvd (St. Paul)	3	465	N/A	18	BD	75	40
H17	Tilsner Apartment Building, 300 Broadway Street (St. Paul)	2	700	N/A	BD	BD	72	35
H18	Commercial Building, 275 4th Street (St. Paul)	3	314	N/A	51	16	75	40
H19	Parkside Apartments, 242 5th Street (St. Paul)	2	268	N/A	58	23	72	35
H20	Apartment Building, 308 Prince Street (St. Paul)	2	675	N/A	BD	BD	72	35
H21	City of St. Paul Mears Park, 220 6th Street (St. Paul)	3	594	N/A	BD	BD	75	40
H22	City of St. Paul Municipal Building, 290 5th Street (St. Paul)	3	493	N/A	8	BD	75	40
H23	City of St. Paul Municipal Building, 290 5th Street (St. Paul)	3	440	N/A	25	BD	75	40

[1/] Closest distance between receptor and the proposed Build Alternative alignments.
[2/] RMS Vibration levels are reported in VdB re 1 μips.
[3/] Ground-borne noise levels are reported in dBA.
[4/] NA = Not Applicable. Vibration levels along the BRT route are not expected to experience elevated vibration levels.
[5/] BD = Below Detection. Vibration levels are predicted to be well below the background levels and are, therefore, not measurable.

4.4.13 Vibration Mitigation

Mitigation measures to reduce the onset of vibration impacts along the Central Corridor from bus and rail operations are described in the following subsections.

UNIVERSITY AVENUE LRT ALTERNATIVE

Exceedances of the FTA vibration impact criteria are predicted along the proposed project corridor from LRT passbys. The impacts are predicted at residences directly adjacent to switches that result in elevated vibration and ground-borne noise levels from LRT train passbys.

Several mitigation measures are recommended to eliminate the predicted impacts including:

- Operating limitations such as speed reductions over the switches
- Strategic placement of switches and crossovers away from vibration-sensitive receptors
- The use of vibration dampening materials, such as ballast mats, under switches in vibration-sensitive locations

UNIVERSITY AVENUE BUSWAY/BRT ALTERNATIVE

No exceedance of the FTA impact criteria is expected anywhere from BRT operations. Therefore, no mitigation measures are currently recommended.

4.5 ECOLOGY AND HABITAT

For purposes of this Ecology and Habitat section, the Central Corridor Study Area was determined to include the area 500-feet on either side of the proposed alignment unless otherwise noted. The proposed LRT and Busway/BRT Alternatives extend from downtown Minneapolis, including the alignment common to the Hiawatha LRT and Northstar Commuter Rail projects, to downtown St. Paul, including the existing Mississippi River crossing to the West Side neighborhood.

This section discusses the existing ecological resources in the Study Area, including vegetation and wildlife, aquatic habitat, wetlands, and reported occurrences of rare, threatened and endangered (RTE) species or critical habitats. Regulations are disclosed, followed by a discussion of the existing conditions for the proposed transit alternatives beginning at the west end of the proposed alignment (Minneapolis) and proceeding east to St. Paul. Following the Existing Conditions section are details regarding the potential impacts and respective mitigation measures to offset the impacts related to the proposed Central Corridor project.

Unlike new development in suburban, rural, or agriculture areas, the proposed Central Corridor project encompasses relatively few natural areas. Former native ecosystems that supported substantial wildlife habitat have been replaced with mostly asphalt and buildings. Wetlands were modified or eliminated; natural stream courses have been placed in channels and culverts. The