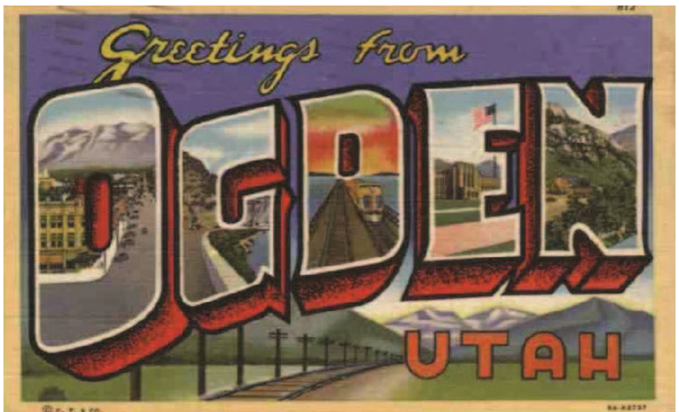
APPENDIX B9

Noise and Vibration Technical Report



Noise and Vibration Technical Report

Ogden/Weber State University Transit Project

Ogden, Weber County, Utah

October 10, 2018

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1.0 Introduction

This technical report describes noise and vibration in the noise and vibration evaluation area for the Ogden/Weber State University Transit Project and evaluates how noise and vibration levels would be affected by the Action Alternative. The Action Alternative is the Bus Rapid Transit on 25th Street Alternative, which was selected by the Ogden/Weber State University Transit Project partners and adopted by the Ogden City Council as the Locally Preferred Alternative.

Implementation of the No-Action Alternative would not result in adverse impacts from noise and vibration. The affected environment (existing conditions) would remain unchanged from current conditions.

Project Study Area. The project study area encompasses a 5.3-mile corridor between downtown Ogden, Weber State University, and McKay-Dee Hospital. The project study area is located in the city of Ogden in Weber County, Utah. The project study area encompasses a portion of downtown central Ogden bounded by the Union Pacific Railroad line to the west, 20th Street (State Route [S.R.] 104) to the north, the city limits at the base of the Wasatch Mountains to the east, and about 4600 South to the south, the southwestern part of which follows the Ogden/South Ogden municipal boundary (Figure 1).

This project study area includes the following major destinations and Ogden neighborhood districts that could be served by the Action Alternative (Figure 2):

- The Ogden Intermodal Transit Center (FrontRunner operates frequent service from Ogden to Provo, an 88-mile route)
- Lindquist Field, a minor-league baseball stadium with an 8,262-person capacity
- The Junction, a 20-acre entertainment, residential, retail, and office mixed-use redevelopment
- The Ogden downtown central business district, which includes city, county, and federal offices
- Seven neighborhood districts: Central Business (downtown), East Central, Taylor, Jefferson, T.O. Smith, Mt. Ogden, and Southeast Ogden
- Ogden High School, with an annual enrollment of about 1,000 students in grades 10–12
- Weber State University, with about 2,500 faculty and staff and about 25,000 students (up from 17,000 in 2007), 840 of whom lived on campus as of September 2016 (Sears 2016)
- The Dee Events Center, a 12,000-seat sports and entertainment venue with a 3,000-space parking lot
- The McKay-Dee Hospital Center (at 2,300 employees, the fourth-largest hospital in Utah)

Figure 1. Project Study Area

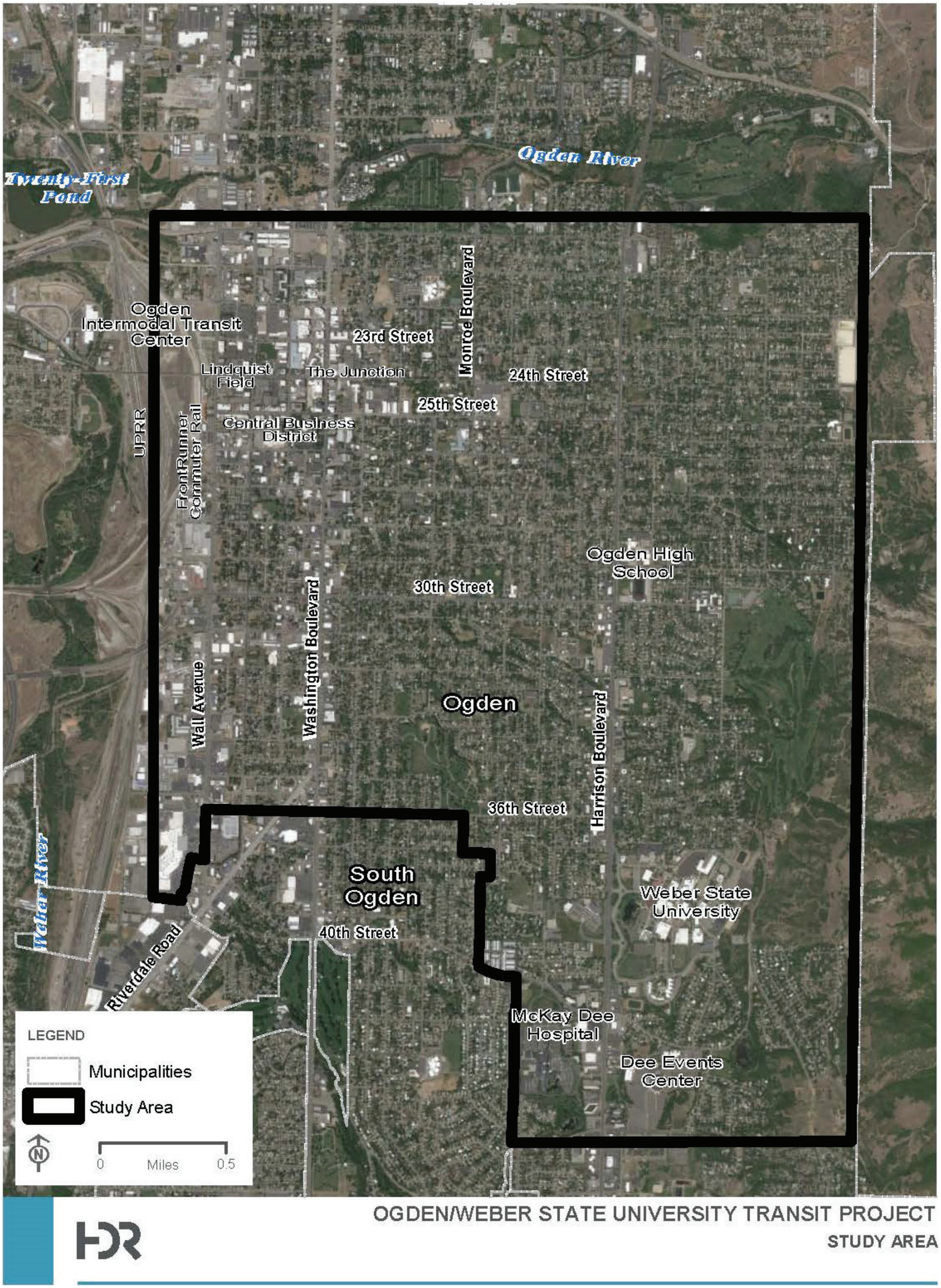
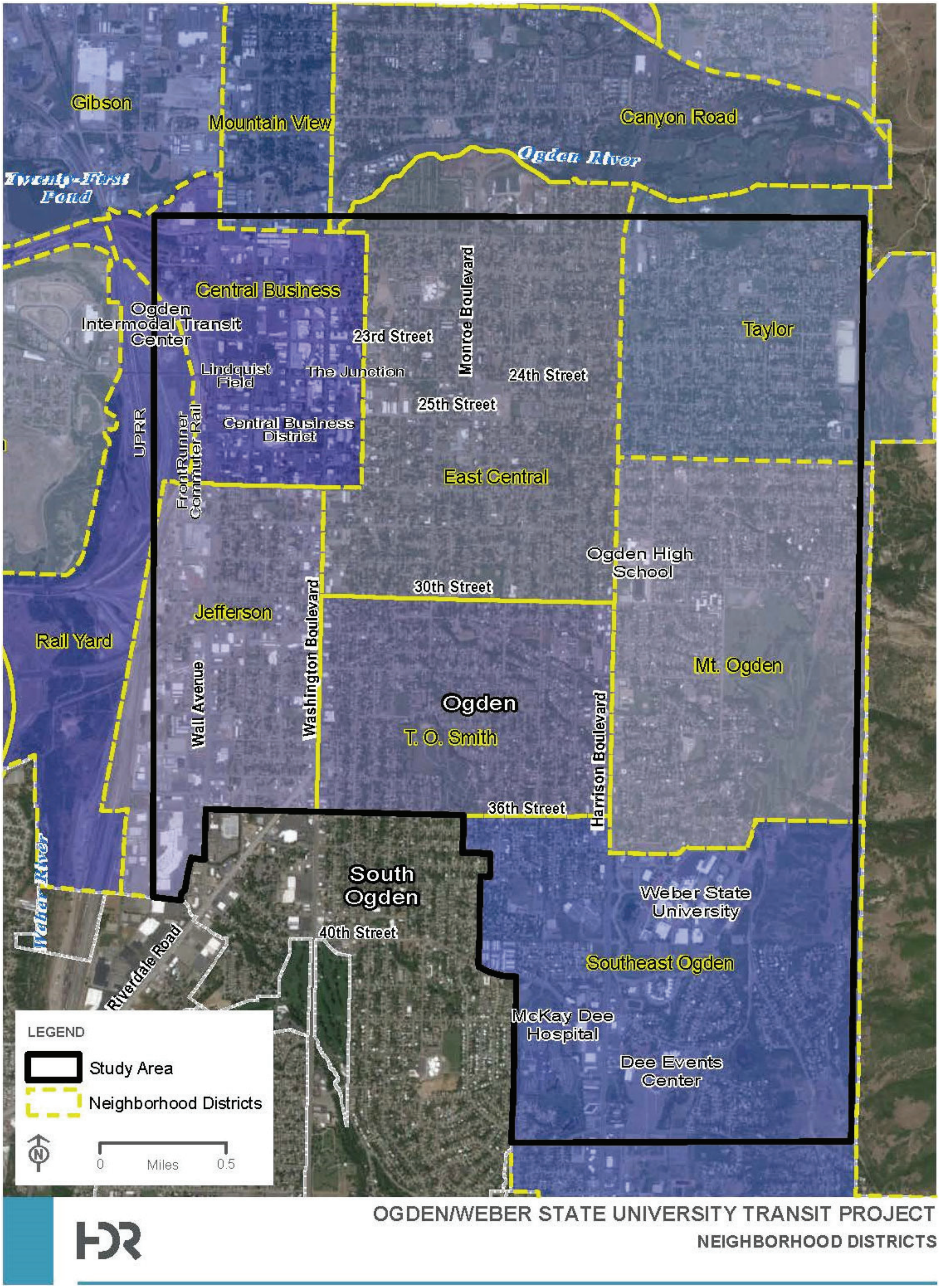


Figure 2. Neighborhood Districts



Ogden is one of the oldest communities in Utah and has a number of historic districts and neighborhoods. Much of central Ogden is served by a traditional grid street system, and a number of the major arterials are state highways managed by the Utah Department of Transportation (UDOT) which serve regional travel through Ogden. These major arterials are Washington Boulevard (S.R. 89), Harrison Boulevard (S.R. 203), and 30th Street (S.R. 79). Harrison Boulevard is part of the National Highway System and is a major north-south arterial that serves an important statewide transportation function through Utah by connecting Washington Boulevard (S.R. 89), Weber State University, and 12th Street (S.R. 39). The Union Pacific Railroad (UPRR) line and the Ogden Intermodal Transit Center are on the western edge of the city, and Interstate 15 is just west of the city.

Noise and Vibration Evaluation Area. The noise and vibration evaluation area is a corridor within about 200 feet of the centerline of the Action Alternative.

2.0 Project Description

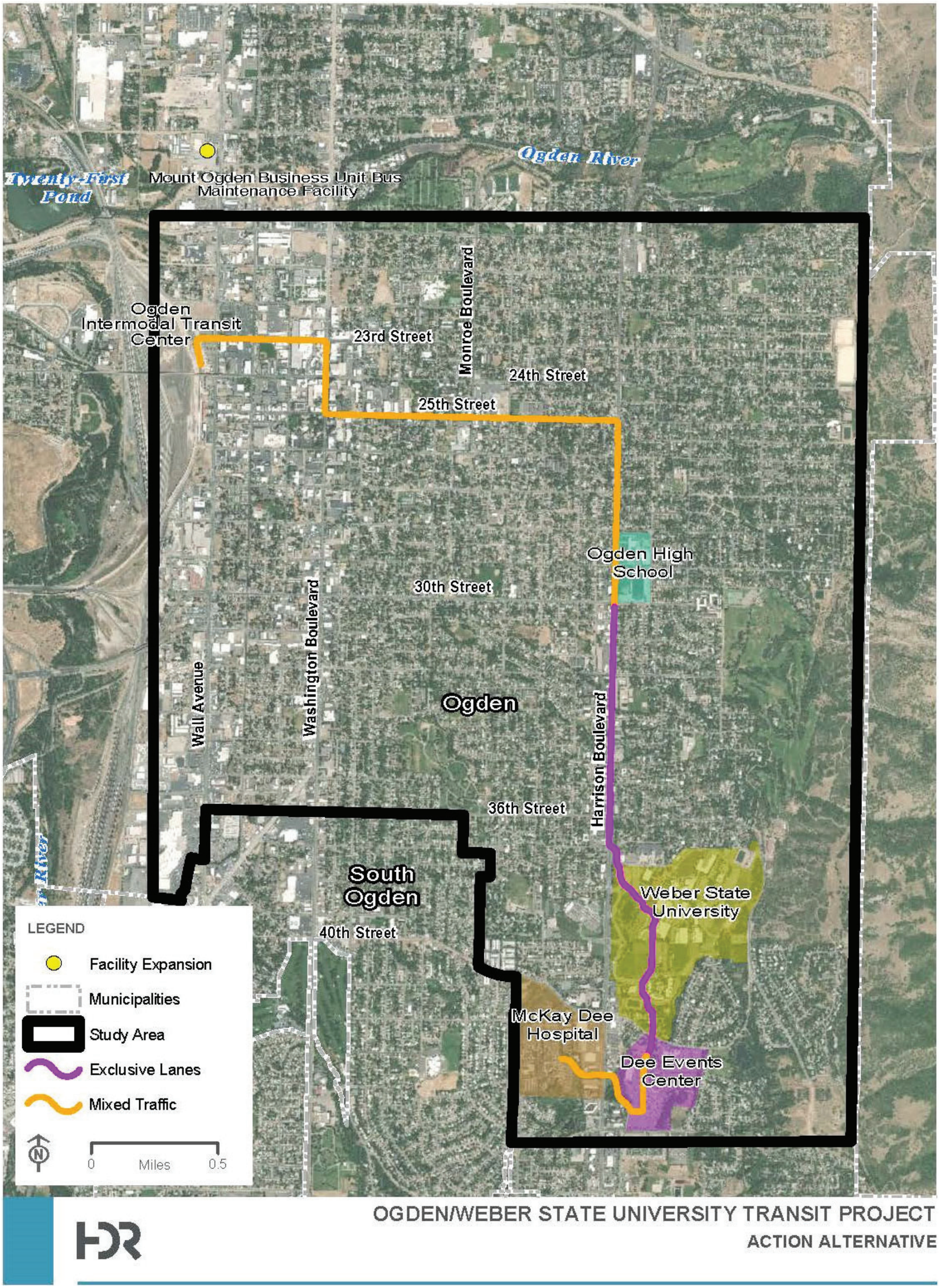
The Federal Transit Administration (FTA) and the Utah Transit Authority (UTA), in cooperation with project partners Ogden City, Weber County, the Wasatch Front Regional Council (WFRC), UDOT, Weber State University, and McKay-Dee Hospital, have prepared an Environmental Assessment under the National Environmental Policy Act (42 United States Code §§ 4321–4347) for the Ogden/Weber State University Transit Project.

Proposed Transit Corridor. The proposed transit corridor is the alignment of the Action Alternative (Figure 3). The bus rapid transit (BRT) route for the Action Alternative would be about 5.3 miles long (10.6 miles round trip), with a western terminus at the Ogden Intermodal Transit Center. From there, the BRT route would head east in mixed-flow traffic on 23rd Street to Washington Boulevard, south on Washington Boulevard to 25th Street, east on 25th Street to Harrison Boulevard, and south on Harrison Boulevard. At about 31st Street and Harrison Boulevard, the BRT route would transition to center-running, bus-only lanes. It would continue on a dedicated busway through the Weber State University campus and then travel west to McKay-Dee Hospital, where it would again travel in mixed-flow traffic. The BRT route would loop back on the same route.

Station Locations. The Action Alternative includes 16 brand-identified stations. The station locations were chosen during the project's Alternatives Analysis update process. Station spacing ranges from about 0.25 mile apart to about 0.50 mile apart; several stations on Harrison Boulevard would be farther apart because of the spacing of major destinations.

Of the proposed 16 stations, 11 are existing bus route 603 stations (including the termini at the Ogden Intermodal Transit Center and McKay-Dee Hospital) that would be enhanced as part of the Action Alternative. The project team agreed that not all 16 stations would be constructed for the BRT service's opening day (2020). Three of the 16 stations are designated as future stop locations. The existing route 603 bus currently stops at two of these three locations, and those locations would be discontinued and new enhanced stations would be constructed in their place in the future based on ridership and station demand.

Figure 3. Action Alternative



Station Amenities. The Action Alternative stations would include a platform, canopy, landscaped planter, and station amenities. The station would sit on a concrete bus pad elevated above the sidewalk curb height between 6 and 9 inches above the street grade. Stations would be about 125 feet long, with a platform length of 100 feet to accommodate two 40-foot-long BRT vehicles. Station shelters would be roughly comparable in size to existing UTA bus passenger shelters in the area, though somewhat longer.

At present, UTA anticipates that the shelters would be designed to include a combination of glass panels and solid support members that would have a minimal visual “footprint.” Station canopies would be opaque features that provide shelter from sun and rain and would be about 10 to 15 feet high, depending on the incorporation of decorative architectural features that would be determined during final design.

The platform provides the area for passenger waiting, boarding, and station amenities. The station platform would range from 8 to 25 feet wide, depending on the station location and the need for a platform to accommodate either single-direction travel or both southbound and northbound travel. Station amenities could include ticket vending machines, seating, lighting, a canopy and wind screens, garbage receptacles, and wayfinding information (maps and signs).

Mount Ogden Business Unit Bus Maintenance Facility Expansion. In conjunction with the Action Alternative, UTA would expand the existing Mount Ogden Business Unit Bus Maintenance Facility located at 175 W. 17th Street in Ogden. The Mount Ogden facility is currently operating at maximum capacity and cannot accommodate the additional eight BRT vehicles needed for the Action Alternative. As a result, the existing Mount Ogden facility would be renovated and expanded.

Operations at the Mount Ogden facility would continue to include maintenance, repairs, inspections, and cleaning for the existing bus fleet and the additional BRT vehicles. The BRT vehicles would be maintained and stored overnight at this facility. The north maintenance building would be expanded to the east by about 8,000 square feet, remaining within property currently owned by UTA and remaining within the existing parking lot pavement area; no additional right-of-way would be required. The expansion would consist of four new bus maintenance bays, which are covered areas for maintaining the new BRT vehicles as well as buses already in the fleet. The expansion would bring the existing facility from about 32,000 square feet to just under 40,000 square feet.

23rd Street and 25th Street Roadway Improvements. To further support the Action Alternative, Ogden City would upgrade portions of 23rd Street and 25th Street to better accommodate the Action Alternative. 25th Street would be rebuilt from the bottom up, and, in certain instances, water mains would be replaced, storm sewers would be installed, and sanitary sewers would be repaired. Depending on the extent of the utility work, curbs might be fully replaced. Ogden City would also upgrade the roadway infrastructure on portions of 23rd Street between Wall Avenue and Kiesel Avenue to better support the Action Alternative and active transportation (walking and bicycling). Improvements would include adding a traffic signal at Lincoln Avenue, restriping, adding bicycle lanes, adding crosswalks, reconstructing curbs, and reconfiguring parking.

3.0 Regulatory Setting

3.1 FTA Noise and Vibration Assessment Guidelines

What is an unobstructed screening distance?

An unobstructed screening distance refers to a clear line of sight between the noise source (such as a bus) and the sensitive receiver (such as a campus dormitory, single-family residence, or other location) without any intervening buildings to block noise.

The Federal Noise Control Act of 1972 (Public Law 92-574) requires that all federal agencies administer their programs in a manner that promotes an environment free from noises that could jeopardize public health or welfare. This noise and vibration impact assessment was prepared in accordance with FTA's guidance manual *Transit Noise and Vibration Impact Assessment* (FTA guidance manual; FTA 2006), which prescribes an unobstructed screening distance for BRT systems on exclusive roadways (such as through the Weber State University campus) of 200 feet (unobstructed) (see Table 4.1, Screening Distances for Noise Assessments, in the 2006 guidance manual). This screening distance was also used for portions of the alignment not on exclusive roadways (that is, operating in mixed-flow traffic) since it is more conservative than the recommended 500 feet (unobstructed) in Table 4.1 of the guidance manual.

The noise screening procedure described in FTA's guidance manual is used to identify locations where a project could cause noise impacts. If no noise-sensitive land uses are present within a defined area of project influence, then no further noise analysis is necessary. The area described by the screening procedure is intended to capture all potentially affected locations.

Based on the design available at the time of the evaluation, the project team used a distance of 70 to 75 feet to represent the distance from the BRT alignment to a potential receiver location at the Weber State University dormitory, the adjacent residential neighborhood, and the McKay-Dee Hospital where a new, dedicated BRT facility could be located.

The guidelines in the FTA guidance manual are specifically used to assess noise and vibration impacts from transit vehicles (for example, buses and light-rail trains) and stationary noise sources associated with transit systems (for example, maintenance facilities and park-and-ride lots). FTA assesses impacts at sensitive receivers such as residences, schools, and libraries. A description of the FTA evaluation criteria and the modeling methodologies is included in Section 3.4, Methods Used To Determine Existing Noise and Vibration Levels.

In addition, this noise analysis follows UTA's *Noise Assessment and Mitigation Procedures* (UTA 2010) for use with all capital development projects. The policy is based on procedures in the FTA guidance manual and in UDOT's most recent Noise Abatement Policy (August 2013).

3.2 Human Perception of Noise

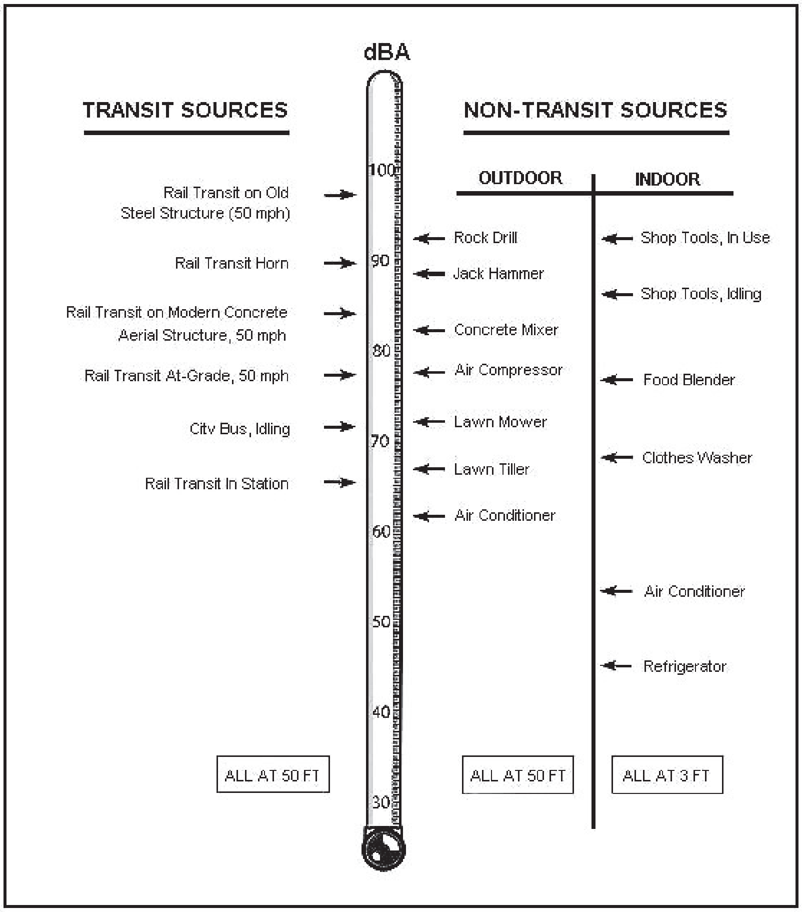
Noise is defined as unwanted sound. Several factors affect the level and quality of sound (or noise) as perceived by the human ear: loudness, pitch (or frequency), and time variation. The *loudness*, or magnitude, of noise determines its intensity and is measured in decibels (dB) that can range from below 40 dB (the rustling of leaves) to over 100 dB (a rock concert). *Pitch* describes the character and frequency content of noise, such as the very low “rumbling” noise of stereo subwoofers or the very high-pitched noise of a piercing whistle. Finally, the *time variation* of noise sources can be characterized as continuous, such as with a building ventilation fan; intermittent, such as for trains passing by; or impulsive, such as pile-driving activities during construction.

Various sound 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 it more closely matches the human ear’s response to audible frequencies. Because the A-weighted decibel scale is logarithmic, a 10-dBA increase in a noise level is generally perceived as a doubling of loudness, while a 3-dBA increase in a noise level is just barely perceptible to the human ear. Typical A-weighted sound levels from transit and other common sources are shown in Chart 1.

Generally, a doubling of traffic volumes on a road will result in a 3-dBA increase in noise levels that could be perceptible to a person with superior hearing. Therefore, if the existing traffic on a road is 5,000 vehicles per day (such as on 25th Street in the evaluation area) and is doubled to 10,000 vehicles per day, the noise level resulting from the doubling of the traffic volume would be about 3 dBA higher.

It is important to note that buses typically make up a small proportion of the overall traffic on a mixed-flow alignment. For example, if the peak-hour traffic volume on 25th Street is 10% of the daily traffic volume (that is, 500 vehicles per hour during the peak hour) and if the existing route 603 bus operates on 25th Street with 15-minute headways (eight buses per hour), then the percentage of buses on 25th Street would be less than 1% of the total hourly traffic volume.

Chart 1. Typical A-Weighted Noise Levels



Source: FTA 2006

Several A-weighted noise descriptors are used to determine the effects of transit-related noise sources. Two of these are the L_{eq}, which represents a level of constant noise with the same acoustical energy as the fluctuating noise levels observed during a given interval [such as 1 hour, written as $L_{eq}(h)$], and the L_{dn}, or the 24-hour day-night noise level, which includes a 10-dBA penalty for all nighttime activity between 10 PM and 7 AM [that is, 10 dBA is added to each $L_{eq}(h)$ during each nighttime hour].

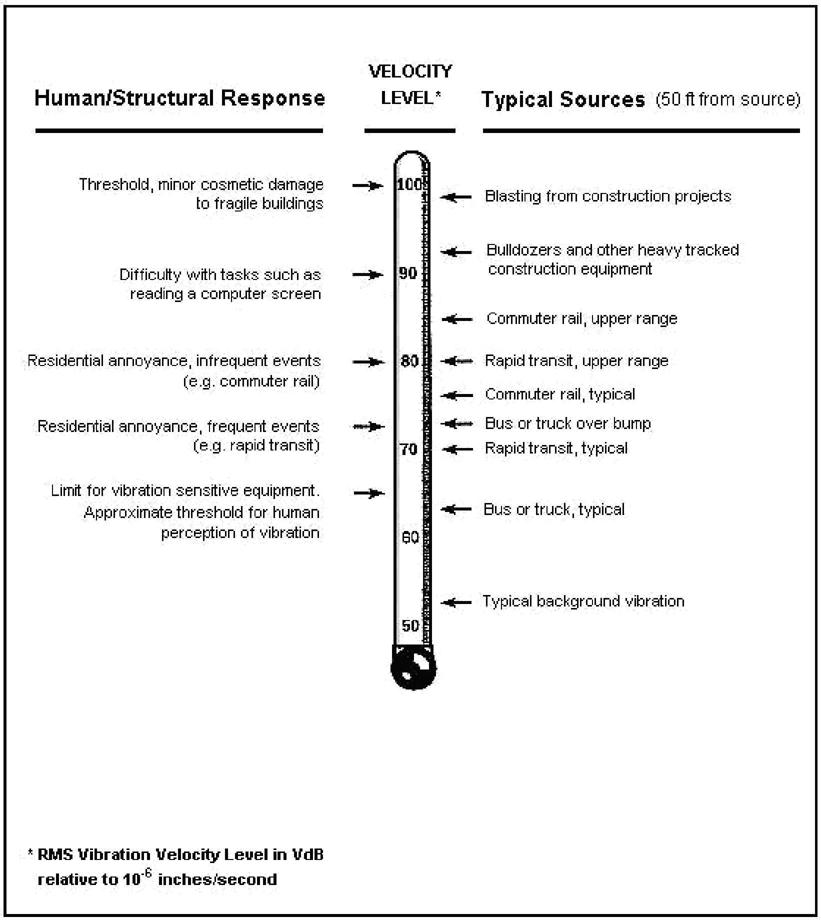
3.3 Human Perception of Vibration

Ground-borne vibration is usually the result of uneven interactions between wheels and the road or rail surfaces. Examples of such interactions that cause ground-borne vibration include train wheels over a jointed rail, an untrue rail car wheel with “flats,” and a motor vehicle tire hitting a pothole, a manhole cover, or any other uneven surface. It is unusual for vibration from rubber-tired sources such as buses and trucks to be perceptible, even in locations close to major roads.

Unlike noise, which travels in air, transit vibration typically travels along the surface of the ground. Depending on the geological properties of the surrounding terrain and the type of building structure exposed to transit vibration, vibration propagation can 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 buildings in sandier soil. On the other hand, heavier buildings (such as masonry structures) are less susceptible to ground-borne vibration than wood-frame buildings because they absorb more of the vibration.

To describe the human response to vibration, the average vibration amplitude (called the root mean square, or RMS, amplitude) is used to assess impacts. The RMS velocity level is expressed in inches per second or vibration decibels (VdB). All VdB vibration levels are referenced to 1 micro-inch per second. Typical ground-borne vibration levels from transit and other common sources are shown in Chart 2.

Chart 2. Typical Ground-Borne Vibration Levels



Source: FTA 2006

3.4 Methods Used To Determine Existing Noise and Vibration Levels

The FTA guidance manual discusses the basic concepts, methods, and procedures for evaluating the extent and severity of noise and vibration impacts from transit projects. Transit noise and vibration impacts are assessed based on land-use categories and sensitivity to noise and vibration from transit sources.

3.4.1 Noise

The FTA land-use categories and the associated noise descriptor for each category are described in Table 1. Category 1 includes uses where quiet is an essential element in their intended purpose, such as indoor concert halls, outdoor concert pavilions, or outdoor National Historic Landmarks where outdoor interpretation routinely takes place. Category 2 land uses include residences and buildings where people sleep, and Category 3 includes institutional land uses with primarily daytime use such as schools and libraries.

Category 2 land uses in the evaluation area include residences on 25th Street, Washington Boulevard, and Harrison Boulevard; residences on Harrison Boulevard between 25th and 32nd Streets; dormitories on the Weber State University campus; the residential neighborhood on 4225 South; and McKay-Dee Hospital. Category 3 land uses include several schools and churches on 25th Street and Harrison Boulevard and non-dormitory buildings on the Weber State University campus. No FTA land-use Category 1 receptors were identified in the evaluation area.

Table 1. FTA Land-Use Categories for Evaluating Transit Noise Impacts

Land-Use Category	Noise Descriptor	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, and 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: FTA 2006

3.4.2 Vibration

Table 2 lists the three categories of land use that FTA considers to be vibration-sensitive. Vibration Category 1 includes vibration-sensitive land uses such as research and manufacturing facilities, hospitals with vibration-sensitive equipment, and university research operations. There are no Vibration Category 1 land uses in the evaluation area. As with the noise impact criteria, the vibration criteria do not apply to most commercial or industrial uses.

Table 2. FTA Vibration Categories

Vibration Category	Description
1 – High Sensitivity	Buildings where vibration would interfere with interior operations. Typical land uses covered by Category 1 are vibration-sensitive research and manufacturing, hospitals with vibration-sensitive equipment, and university research operations.
2 – Residential	All residential land uses and any buildings where people sleep, such as hotels and hospitals.
3 – Institutional	Schools, churches, other institutions, and quiet offices that do not have vibration-sensitive equipment but whose activities could still experience interference from vibration.

Source: FTA 2006

4.0 Affected Environment

4.1 Existing Noise Levels on 25th Street and Harrison Boulevard

The BRT route for the Action Alternative would be about 5.3 miles long (10.6 miles round trip), with a western terminus at the Ogden Intermodal Transit Center. From there, the BRT route would head east on 23rd Street to Washington Boulevard, south on Washington Boulevard to 25th Street, east on 25th Street to Harrison Boulevard, and south on Harrison Boulevard through the Weber State University campus and then west to McKay-Dee Hospital. The BRT route would loop back on the same route. The BRT system would include new 40-foot-long buses that would operate about every 10 to 15 minutes in mixed-flow traffic along the existing corridor right-of-way, then in a center-running, bus-only lane on Harrison Boulevard south of 31st Street and through the university campus (see Figure 3 above), then back to mixed flow through the McKay-Dee Hospital campus.

UTA and Ogden City are considering using hybrid diesel-electric buses, which use both diesel fuel and zero-emission electric batteries. The goal will be to provide a rapid, high-quality, brand-distinguished bus service that provides the same level of service as rail transit (in terms of frequency, capacity, quality, and reliability) except with greater flexibility, lower capital and operating investment costs, and likely reduced transportation-related energy use, air pollution, and greenhouse gas emissions.

Mixed Flow. The segment of the alignment north of 31st Street would operate in mixed flow, just like the existing route 603 bus currently does.

In the areas of mixed-flow traffic, existing noise levels are higher because of existing traffic on 23rd Street, Washington Boulevard, 25th Street, and Harrison Boulevard. (Average daily traffic volumes are about 5,000 vehicles per day on 25th Street and about 32,000 vehicles per day on Harrison Boulevard; traffic volumes on Harrison Boulevard are projected to increase to about 40,000 vehicles per day in 2040.) As discussed in Section 3.2, Human Perception of Noise, buses typically make up a small percentage of traffic on roads and are a small component of the overall noise levels experienced by residents who live near a road.

Because 25th Street is a quieter, more residential neighborhood than is Harrison Boulevard, the project team prepared a simplified noise model to assess noise levels on 25th Street to reflect the traffic on this mixed-flow alignment. The results of that evaluation are discussed in Section 5.3.1, Operational Noise and Vibration Impacts.

Bus-Only Travel Lanes. Between 31st and 37th Streets, Harrison Boulevard would be widened to the west to accommodate the bus-only lanes in the center of Harrison Boulevard while keeping the general-purpose travel lanes in their current configuration. Widening Harrison Boulevard to the west would avoid moving general-purpose traffic closer to homes south of 31st Street.

Harrison Boulevard is a principal arterial in a more urbanized part of Ogden, so residents who live on Harrison Boulevard experience louder traffic noise than do residents who live on 25th Street. The existing noise levels on Harrison Boulevard are due to the high volume of vehicle traffic, though transit buses are a very small component of this daily traffic volume (less than 1% of the daily volume). Based on the project team's experience with similar projects on busy principal arterials, outdoor locations with direct line of sight to Harrison Boulevard (that is, front lawn or front porch locations) would likely experience noise levels in the range of 70 dBA to 75 dBA, depending on the volume of pass-by traffic. Both residents who live on 25th Street and those who live on Harrison Boulevard would engage in most residential outdoor activities in backyard locations (for example, patios) where noise levels would be lower due to the sound attenuation (reduction) provided by the house itself.

Applying the building noise reduction factors listed in Table 3 below, it is reasonable to assume that interior noise levels at residences on Harrison Boulevard would be reduced by 20 dBA to 30 dBA over the noise level experienced in a front yard. So even if, for example, an outdoor noise level was 75 dBA, after applying reduction factors from the building material and window condition, the noise level inside the residence could be 45 dBA to 55 dBA.

Furthermore, the loudest noise levels would not be experienced at all hours of the day or night. During the evening hours, traffic volumes on Harrison Boulevard are much lower and, consequently, noise levels at individual residences would be much lower as well.

There is no reason to expect that the very low volume of transit buses operating on Harrison Boulevard would cause significant noise impacts.

Exterior and Interior Noise. The project team recognizes that residents who live on 25th Street and Harrison Boulevard experience some level of traffic noise because of their close proximity to the street. Residents of Harrison Boulevard experience higher traffic-related noise than do residents on 25th Street because of the higher traffic volumes and vehicle speeds on Harrison Boulevard compared to those on 25th Street.

It is reasonable to assume that, at most homes on 25th Street and Harrison Boulevard, the exterior areas that residents most likely use are patio and backyard locations without a direct line of sight to either 25th Street or Harrison Boulevard. Noise levels in such locations would be lower because of the attenuation provided by the home itself.

The project team also estimated interior noise levels by applying reduction factors using FHWA guidance (FHWA 2011). Table 3 shows the reduction factors attributable to the building type and window condition of the home.

Table 3. Building Noise Reduction Factors

Building Type	Window Condition	Noise Reduction due to Exterior of Structure (dBA)
All	Open	10
Light frame	Ordinary sash (closed)	20
	Storm windows	25
Masonry	Single-glazed	25
	Double-glazed	35

Source: FHWA 2011

Many of the homes on 25th Street are of masonry construction; therefore, based on Table 3 above, it is reasonable to assume that interior noise levels would be anywhere from 25 dBA to 35 dBA or more lower than those modeled at outdoor front-yard locations. Even though modeling was not conducted at residences on Harrison Boulevard, it is reasonable to assume that interior noise levels would be lower at those homes as well, though background noise is higher due to the higher existing traffic levels on Harrison Boulevard.

Near 37th Street, the Action Alternative would leave Harrison Boulevard and proceed south through the Weber State University campus and through a residential development between 4225 South and Country Club Drive on a dedicated (that is, new) BRT alignment.

Because of the absence of other noise sources, noise levels on the dedicated BRT alignment would be much lower than those on Harrison Boulevard or other arterials. The alignment would then cross Harrison Boulevard on 4400 South and proceed through the McKay-Dee Hospital property on an existing bus route.

4.2 Existing Noise Levels on the Weber State University and McKay-Dee Hospital Campuses

On the new portion of the alignment through the Weber State University campus, existing noise levels were measured at three locations representative of Category 2 noise-sensitive receptor locations (residential locations and places where people sleep) as shown in Figure 4 through Figure 6. At McKay-Dee Hospital, the BRT alignment would operate in mixed flow on the existing roadway through the hospital campus. Measurement sites were selected in conjunction with representatives from Weber State University (who recommended a campus dormitory location and a residential location in the neighborhood around 4225 South) and McKay-Dee Hospital (who recommended a location that would represent patient rooms). All three locations had unobstructed views of the proposed BRT alignment.

A 24-hour noise measurement was taken at each measurement site on Thursday, July 28, 2016, and Monday, August 8, 2016. The 24-hour noise measurements were taken at nearby outdoor locations where noise levels due to the project would be higher than at the indoor locations (such as dormitory rooms, patient rooms, or residential bedrooms). In buildings with masonry construction, indoor noise levels would be anywhere from 20 dBA to 25 dBA lower than noise levels measured at the nearby outdoor location (FHWA 2011).

Table 4 on page 19 shows the measured 1-hour L_{eq}, 24-hour L_{eq} and 24-hour L_{dn} values at each measurement location. As shown in Table 4, the 24-hour L_{eq} ranged from 54 dBA in the residential neighborhood around 4225 South to 59 dBA at the Weber State University dormitory location. The 24-hour L_{dn} ranged from 58 dBA to 59 dBA at the same locations. Measured noise levels were typical of the sound levels expected in relatively quiet locations not affected by other noise sources such as traffic on nearby arterial roads.

4.3 Existing Vibration Levels

Existing vibration effects in the evaluation area are primarily due to traffic on heavily traveled streets such as 23rd Street, 25th Street, Washington Boulevard, and Harrison Boulevard. There are no operating railroads or other sources of vibration in the evaluation area that that contribute to existing vibration effects.

Figure 4. Noise Monitoring Location 1 – Weber State University Dormitory

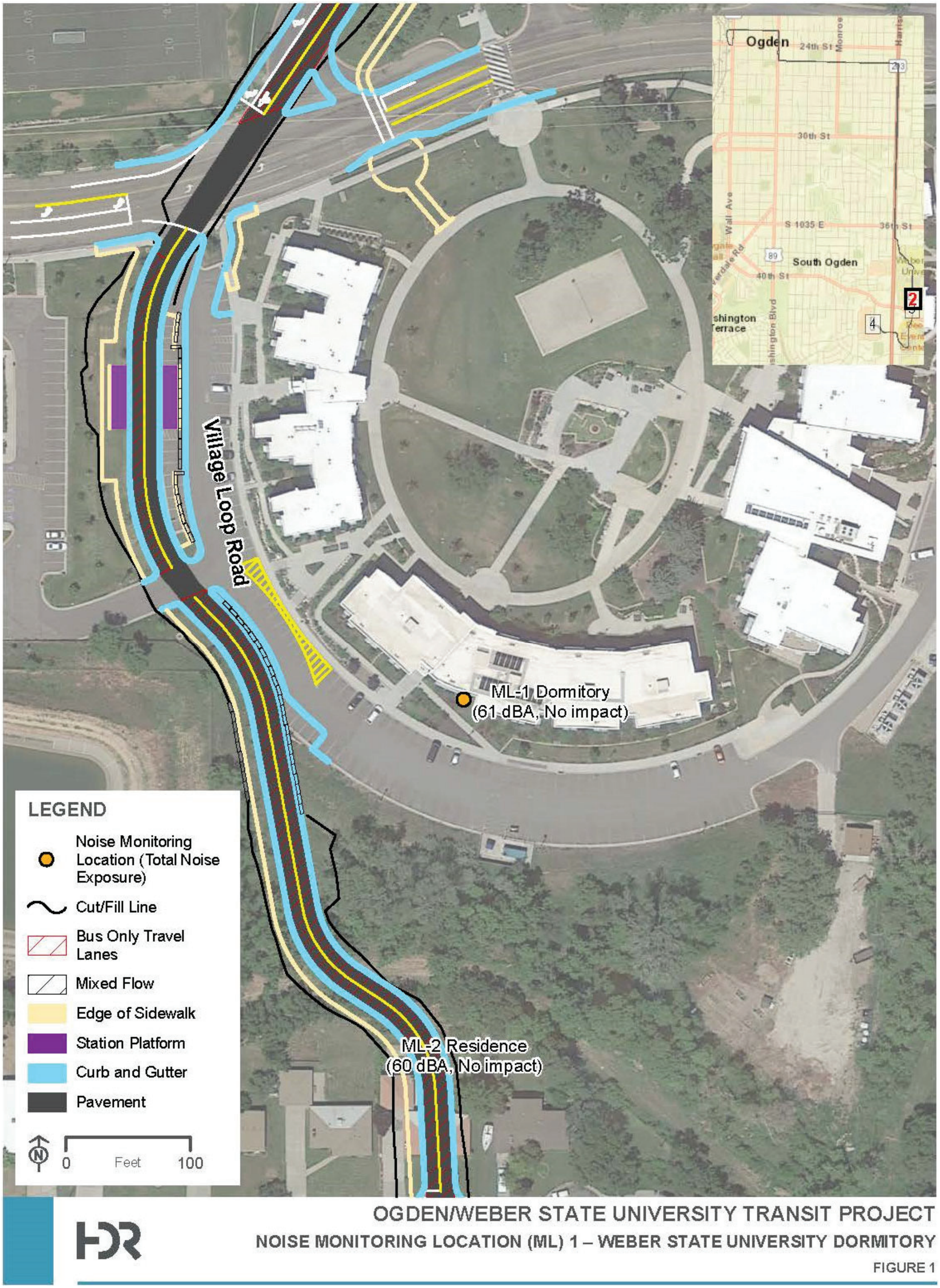


Figure 5. Noise Monitoring Location 2 – 4225 South Residential Area

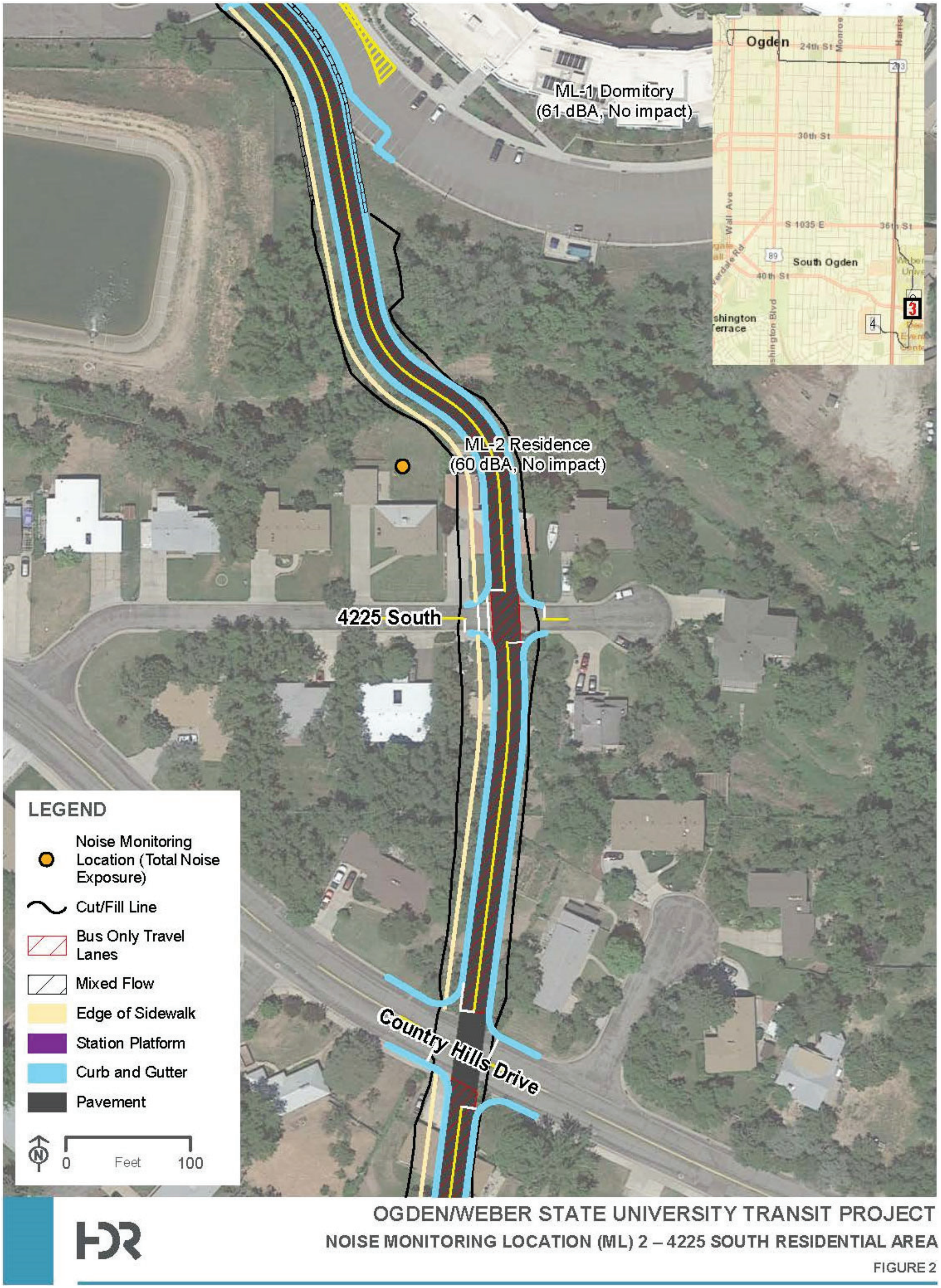


Figure 6. Noise Monitoring Location 3 – McKay-Dee Hospital

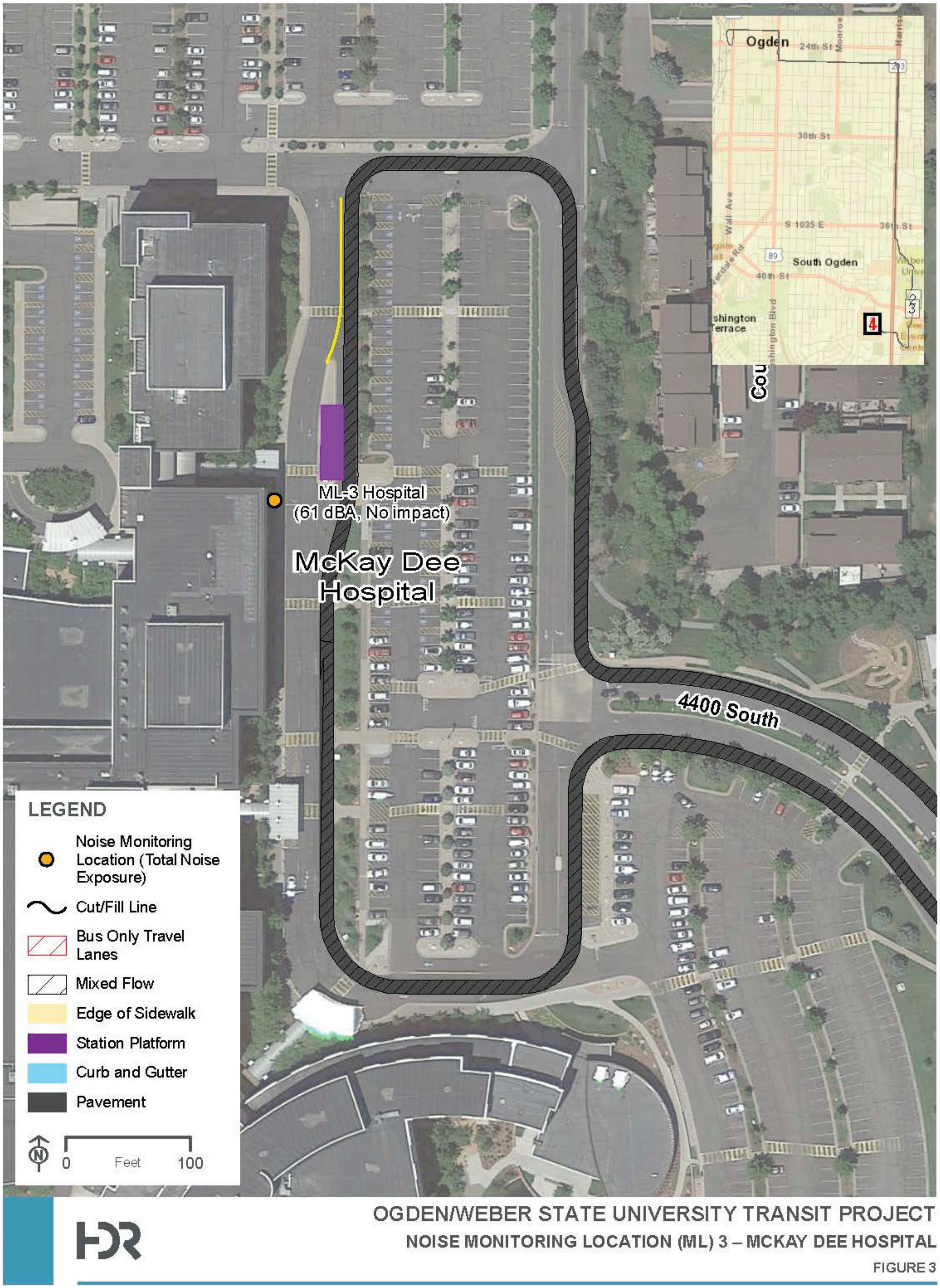


Table 4. Measured Noise Levels

Interval	Start Time	End Time	Weber State University Dormitory Measured 24-hour L_{dn} – 59 dBA Measured 24-hour L_{eq} – 52 dBA	Residential Neighborhood (4225 South) Measured 24-hour L_{dn} – 58 dBA Measured 24-hour L_{eq} – 54 dBA	McKay-Dee Hospital Measured 24-hour L_{dn} – 59 dBA Measured 24-hour L_{eq} – 55 dBA
			$L_{eq}(h)$	$L_{eq}(h)$	$L_{eq}(h)$
1	13:00	14:00	56	60	57
2	14:00	15:00	50	60	58
3	15:00	16:00	49	53	57
4	16:00	17:00	43	45	56
5	17:00	18:00	54	46	57
6	18:00	19:00	41	46	555
7	19:00	20:00	42	45	55
8	20:00	21:00	44	47	55
9	21:00	22:00	54	50	55
10	22:00	23:00	54	53	51
11	23:00	0:00	54	52	52
12	0:00	1:00	54	52	51
13	1:00	2:00	54	51	48
14	2:00	3:00	55	50	50
15	3:00	4:00	54	48	47
16	4:00	5:00	51	46	49
17	5:00	6:00	45	45	52
18	6:00	7:00	46	48	54
19	7:00	8:00	47	51	55
20	8:00	9:00	48	55	56
21	9:00	10:00	47	56	54
22	10:00	11:00	53	57	56
23	11:00	12:00	59	59	56
24	12:00	13:00	47	60	57

5.0 Environmental Consequences

This section describes the expected noise and vibration impacts of the Action Alternative. A General Noise Assessment was conducted according to FTA procedures and guidelines using measured noise levels from the 24-hour measurements, existing noise sources in the area, and the noise sources that would be added by the Action Alternative. As stated in the FTA guidance manual, a General Noise Assessment can provide the appropriate level of detail about noise impacts for a variety of smaller transit projects or when an environmental document (such as a Draft Environmental Impact Statement) is being prepared (FTA 2006). Noise levels on 25th Street and Harrison Boulevard were estimated by using a simplified noise model on 25th Street, which is a quieter, more residential neighborhood with lower traffic volumes than Harrison Boulevard. Because the environmental document for the Ogden/Weber State University Transit Project is an Environmental Assessment, a General Noise Assessment is appropriate for the transit-only component of the project.

5.1 Transit Noise and Vibration Evaluation Criteria

The FTA guidance manual presents the basic concepts, methods, and procedures for evaluating the extent and severity of noise and vibration impacts from transit projects. Noise and vibration impacts are assessed based on land-use categories and these uses' sensitivity to noise and vibration from transit sources.

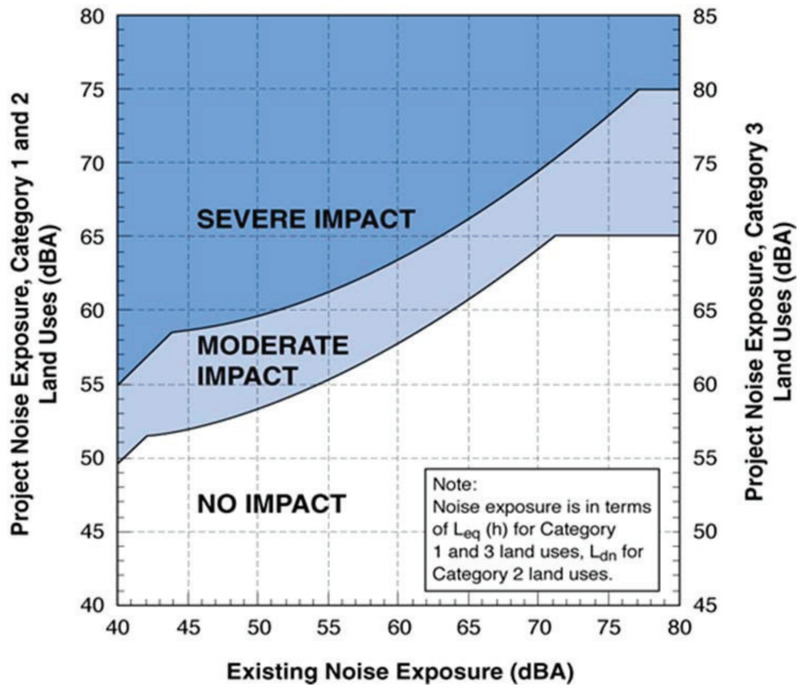
5.1.1 Noise Criteria

As shown in Chart 3, the FTA transit noise impact criteria define noise impacts in terms of the existing noise levels, the expected noise levels with the proposed project, and the land uses that would be affected. Category 1 and 2 land uses are more sensitive to noise than are Category 3 land uses (see Table 1 above).

The FTA noise criteria separate noise impacts into two categories: *moderate impacts* and *severe impacts*. The *moderate impact* category indicates that the change in noise is noticeable but might not be sufficient to cause a strong, adverse community reaction. The *severe impact* category indicates that a significant percentage of the population would be highly affected by the new noise. The degree of impact at any specific location can be determined by comparing the predicted project noise level at the site to the existing noise level.

Noises affect people differently due to their environment and other various factors. Loud noises such as a car honking its horn would bother most people while they were trying to sleep, while a softer noise during the day might bother certain individuals if they were trying to study or concentrate on a difficult task. FTA has developed noise impact criteria for transit projects to determine when impacts occur (**Error! Not a valid bookmark self-reference.**). Noise impacts are based on comparing existing outdoor noises levels with the future noise levels of proposed transit projects. This analysis includes the consideration of absolute noise levels and the increase over existing levels in order to determine the severity of the impact caused by the project. An increase of 3 dBA is barely perceptible, an increase of 5 dBA is noticeable, and ta 10-dBA increase would be perceived by someone to be a doubling of the noise level (loudness). Increases of 5 to 10 dBA would tend to be noticeable to most people but not substantial. An increase of 10 dBA or more would be perceived by most people as a substantial impact.

Chart 3. FTA Transit Noise Impact Criteria



Source: FTA 2006

5.1.2 Vibration Criteria

The FTA vibration criteria for evaluating ground-borne vibration impacts are shown in Table 5. The vibration criteria are related to ground-borne vibration levels that are expected to result in human annoyance and are based on root-mean-square (RMS) velocity levels expressed in velocity decibels (VdB) referenced to 1 micro-inch per second.

FTA's experience with community response to ground-borne vibration indicates that, when only a few vibration-inducing events occur per day (for example, trains passing by a residential development), it takes higher vibration levels to evoke the same community response that occurs from more-frequent events. This is taken into account in the FTA vibration criteria by distinguishing between projects with *frequent*, *occasional*, and *infrequent* vibration events. The *frequent events* category is defined as more than 70 vibration-inducing events per day (and is the criterion appropriate for the Action Alternative), the *occasional events* category is defined as between 30 and 70 events per day, and the *infrequent events* category is defined as fewer than 30 events per day. In addition, transit projects involving rubber-tired buses rarely cause vibration effects.

Table 5. FTA Ground-Borne RMS Vibration Impact Criteria

Receptor Land Use		RMS Vibration Levels (VdB) [a]		
Category	Description	Frequent Events	Occasional Events	Infrequent Events
1	Buildings where low vibration is essential for interior operations	65	65	65
2	Residences and buildings where people normally sleep	72	75	80
3	Daytime institutional and office use	75	78	83
Specific buildings	TV or recording studios, concert halls	65	65	65
	Auditoriums	72	80	80
	Theaters	72	80	80

Source: FTA 2006

[a] Ground-borne vibration levels (VdB) are referenced to 1 micro-inch per second.

5.1.3 Modeling Methodology

Noise

The existing noise levels described in Section 4.0, Affected Environment, were used to assess the expected noise impacts from the Action Alternative. The FTA Noise Impact Assessment Spreadsheet model (HMMH 2007) was used to assess the expected noise impacts in the evaluation area for the operation of rubber-tired buses operating with 10-minute headways in each direction (12 pass-by events per hour). On the Weber State University campus, a second noise source was included in the model to represent the campus shuttle that would operate between the Dee Events Center and the University's main campus with 5-minute headways (24 pass-by events per hour) between 7 AM and 2 PM. A speed limit of 20 miles per hour (mph) was assumed through the Weber State University campus, the residential neighborhood around 4225 South, and the McKay-Dee Hospital property where pedestrians would likely be walking.

The proposed BRT hours of operation are from 4:30 AM to 12:30 AM.

Since there would be no transit stations other than platforms that would include weather protection, heating, bicycle racks, and off-board ticketing, these sources were not included in the evaluation.

Because the most noise-sensitive land uses along the proposed BRT alignment are residential (Category 2 land uses), the L_{dn} descriptor was used to reflect the heightened sensitivity of residents to nighttime noise (the L_{dn} adds an additional 10 dBA of noise to nighttime noise levels to account for the increased sensitivity to noise at night, when most people are sleeping).

Vibration

Vibration impacts from the Action Alternative were considered using FTA's vibration screening procedure for bus and rubber-tire transit projects. As discussed in the FTA guidance manual, buses with rubber tires and effective suspension systems rarely cause ground-borne vibration impacts. Most vibration impacts are attributable to potholes, substantial bumps in the road, expansion joints, or other discontinuities in the road surface. Smoothing the bump or filling the pothole will usually solve any vibration issue associated with a bus project.

5.2 No-Action Alternative

With the No-Action Alternative, the BRT and other facilities associated with the Action Alternative would not be constructed. The No-Action Alternative includes the existing transportation system and all projects in WFRC's 2015–2040 Regional Transportation Plan that are programmed to be completed within the project study area by 2020, the anticipated opening year for the Action Alternative's BRT.

The No-Action Alternative includes current UTA route 603 bus service in the proposed transit corridor using standard buses. The existing bus and automobile traffic would be the same as with the existing conditions; therefore, noise levels with the No-Action Alternative would be the same as those with the existing conditions.

5.3 Action Alternative

5.3.1 Operational Noise and Vibration Impacts

This section describes the operational noise and vibration impacts from the Action Alternative. The project team conducted both a qualitative assessment and the FTA General Noise Assessment to determine the noise impacts from the Action Alternative at sensitive land uses in the evaluation area.

Noise Impacts

25th Street. As discussed in Section 4.0, a simplified noise model was developed to represent mixed-flow traffic on 25th Street. Thirteen receptors were included in the model and located in front-yard locations with direct line of sight to 25th Street. Therefore, these receptors represent worst-case, outdoor areas with direct exposure to pass-by traffic on 25th Street. Modeled noise levels on 25th Street ranged from 64 dBA to 65 dBA and were below the residential noise abatement criteria (NAC) if noise levels were being evaluated under the UDOT Noise Abatement Policy (UDOT 08A2-01, June 15, 2017). Also, as shown in Table 3 above, interior noise levels would be substantially lower due to the noise attenuation (reduction) provided by the building material (for example, masonry brick or wood frame) and the condition of the windows (storm windows or double-glazed).

Harrison Boulevard. As described in Section 4.0, Harrison Boulevard is a principal arterial in a more urbanized part of Ogden, so residents who live on Harrison Boulevard experience louder traffic noise than do residents who live on 25th Street. Based on the project team's experience with similar projects on busy principal arterials, outdoor locations with direct line of sight to Harrison Boulevard (that is, front lawn or front porch locations) would likely experience noise levels in the range of 70 dBA to 75 dBA depending on the volume of pass-by traffic. Based on the existing high volume of traffic (about 32,000 average daily traffic), the fact that bus traffic is only about 1% of overall traffic, and the fact that the roadway widening would not place the general-purpose lanes closer to homes, the project team does not expect that the very low volume of transit buses operating on Harrison Boulevard would cause significant noise impacts beyond the existing noise levels.

Weber State University and McKay-Dee Hospital Campuses. The project team estimated noise effects from the Action Alternative using FTA's Noise Impact Assessment Spreadsheet (HMMH 2007). The operational noise from buses was combined with the existing noise level (as determined from the 24-hour noise measurements). The resulting noise level was then compared to the FTA transit noise impact criteria (see Chart 3 above) to determine whether the Action Alternative would cause noise impacts.

Table 6 shows the operational noise impacts from the Action Alternative at the three locations monitored for this project using the hours of operation discussed above in Section 5.1.3, Modeling Methodology. In addition, the operational impacts do not include indoor noise reduction from masonry or other building materials at the University dormitory, other residences in the vicinity of the BRT alignment, or hospital sites.

As shown in Table 6, there would be no noise impacts at the evaluated Category 2 locations.

Table 6. Noise Impacts in the Noise and Vibration Evaluation Area

Location	General Land-Use Category	Noise Level (dBA)[a]				Impacts
		Existing[b]	Project Noise[c]	Total Noise Exposure (Existing + Project)	Noise Exposure Increase due to Project[d]	
1 – Weber State University dormitory[d]	Residential (Category 2)	59	56	61	2	No impact
2 – Residences (4225 South)	Residential (Category 2)	58	55	60	2	No impact
3 – McKay-Dee Hospital	Residential (Category 2)	59	55	61	1	No impact

[a] Source: HMMH 2007

[b] The noise descriptor for Category 2 residential land uses is the 24-hour L_{dn} where nighttime sensitivity is a factor.

[c] Project noise is noise due to operation of the bus system, not including existing noise. Input parameters for the calculations are included in the noise impact assessment spreadsheets in Appendix A, FTA Noise Impact Assessment Spreadsheets, of this report.

[d] Includes operational noise from the on-campus shuttle service between 7 AM and 2 PM.

Vibration Impacts

Because the Action Alternative includes the use of rubber-tired vehicles, the project team does not anticipate any vibration impacts. A screening-level vibration evaluation was prepared using the guidelines recommended by FTA (2006) for such analyses.

The screening-level vibration evaluation considered the following three specific factors:

1. *Will there be expansion joints, speed bumps, or other design features that result in unevenness in the road surface near vibration-sensitive buildings? Such irregularities can result in perceptible ground-borne vibration at distances of up to 75 feet away.*

   According to FTA guidelines, vibration-sensitive buildings include vibration-sensitive research and manufacturing facilities, hospitals with vibration-sensitive equipment, and university research operations. Equipment such as electron microscopes and high-resolution lithographic equipment can be sensitive to vibrations.

   Evaluation. Some buildings, such as concert halls, recording studios, and theaters, can be sensitive to vibration but do not fit into any of the three categories described above and listed in Table 5 above. Within the proposed project corridor, these buildings include the Val A. Browning Performing Arts Center and the Kimball Visual Arts Center on the Weber State University campus. The University has provided substantive input into the proposed BRT alignment through the campus. The proposed alignment would pass within about 50 to 60 feet of both the Browning Performing Arts Center and the Kimball Visual Arts Center.

   The Browning Performing Arts Center houses performance theatres, scenery-construction space, rehearsal rooms, and several classrooms. The Kimball Visual Arts Center houses classrooms, studios, and galleries. There are no vibration-sensitive operations as listed in Table 4 above at either facility.

   Significant vibration impacts from rubber tire–fitted vehicles are rare. The rubber tires and suspension systems of buses isolate vibration, so it is unusual for buses to cause a significant amount of ground-borne noise or vibration. Perceptible vibration from buses can result from bumps, potholes, gaps, or other disruptions in the roadway surface.

   Because the busway through the Weber State University campus would be newly constructed, the potential for poor roadway surface conditions that could lead to vibration potential would be negligible. In addition, the buses would operate at low speed (about 20 mph) through the Weber State University segment of the BRT alignment, further reducing the potential for vibration impacts.

   In addition, the project partners are considering using all-electric or hybrid diesel-electric buses. The magnitude of vibrations and emissions from electric vehicles is less than that from conventional gasoline-powered vehicles (Chen 2015). Apart from the reduction in emissions, electric buses operate with lower noise and vibration due to the absence of mechanical parts compared to conventional diesel buses (Teoh et al. 2017). Therefore, little to no vibration impacts are expected from the Action Alternative that would adversely affect activities at the Browning Performing Arts Center or the Kimball Visual Arts Center.

At McKay-Dee Hospital, the buses would run on an existing alignment next to the hospital with an operational bus route. There have been no vibration issues identified with the existing route 603 bus operation at this location, and none are expected from the Action Alternative.

2. *Will buses, trucks, or other heavy vehicles be operating close to a sensitive building? Research using electron microscopes and manufacturing of computer chips are examples of vibration-sensitive activities.*

   Evaluation. The alignment through the university campus would be for the exclusive use of rubber-tired buses, and no trucks or other heavy vehicles would use the alignment. There are no vibration-sensitive activities adjacent to the proposed alignment on the campus, and vehicles (including cars and trucks) currently using the existing route through the McKay-Dee Hospital property have not led to vibration complaints.

3. *Does the project include operation of vehicles inside or directly underneath buildings that are vibration-sensitive? Special considerations are often required for shared-use facilities such as a bus station located inside an office building complex.*

   Evaluation. The proposed BRT alignment does not include the operation of vehicles underneath buildings.

Based on the above considerations, vibration impacts are unlikely, and no further analysis is required.

5.3.2 Construction Noise and Vibration Impacts

Though noise from constructing the Action Alternative would be temporary, it could be a nuisance at nearby locations. Noise levels during construction are difficult to predict, and they vary depending on the types of construction activity and the types of equipment used for each stage of work. Heavy machinery, which is the major source of noise in construction, is constantly moving in unpredictable patterns and is not usually at one location for very long.

Project construction activities can include constructing new alignments, roadway reconstruction and paving, and relocating utilities, among others. No heavy-duty impulsive equipment, such as pile drivers, is anticipated for constructing the Action Alternative.

Construction normally occurs during daylight hours when some residents are not at home, when residents who are at home are less sensitive to construction activities, and when other community noise sources contribute to higher ambient noise levels. Since UTA does not expect any of the noise receptors in the evaluation area to be exposed to construction noise for a long time, extended disruption of normal activities is not expected. Construction noise is also intermittent and depends on the type of operation, the location, and the function of the equipment as well as the equipment usage cycle.

5.3.3 Mitigation Measures for Noise and Vibration Impacts

Mitigation Measures for Noise Impacts

As shown in Table 6 above, there would be no noise impacts from the Action Alternative. Therefore, no mitigation is required.

Mitigation Measures for Vibration Impacts

No vibration impacts from the Action Alternative were identified; therefore, no mitigation measures are proposed.

6.0 References

Chen, Jia-Shun

2015 Vibration reduction in electric bus during acceleration and gear shifting. *Advances in Mechanical Engineering* 2015 Special Issue: 1–16. http://journals.sagepub.com/doi/pdf/10.1177/1687814015575992.

[FHWA] Federal Highway Administration

2011 Highway Traffic Noise: Analysis and Abatement Guidance.

[FTA] Federal Transit Administration

2006 Transit Noise and Vibration Impact Assessment. May.

[HMMH] Harris Miller & Hanson, Inc.

2007 Federal Transit Administration, Noise Impact Assessment Spreadsheet.

Sears, Craig

2016 Personal communication between Heidi Spoor of HDR and Craig Sears of Weber State University regarding Weber State University student demographics. September 12.

Teoh, Lay Eng, Hooi Ling Khoo, Siew Yoke Goh, and Lai Mun Chong

2017 Scenario-based electric bus operation: A case study of Putrajaya, Malaysia. *International Journal of Transportation Science and Technology* September 28. https://www.sciencedirect.com/science/article/pii/S2046043017300540.

[UTA] Utah Transit Authority

2010 Noise Assessment and Mitigation Procedures. September 24.

Appendix A. FTA Noise Impact Assessment Spreadsheets

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Federal Transit Administration
Noise Impact Assessment Spreadsheet
Copyright 2007 HMMH Inc.
version: 7/3/2007

Project:	**Weber State University Dormitory**

Receiver Parameters	
Receiver:	**Weber State Dorm**
Land Use Category:	**2. Residential**
Existing Noise (Measured or Generic Value):	**59 dBA**

Noise Source Parameters	
Number of Noise Sources:	2

Noise Source Parameters		Source 1
	Source Type:	Highway/Transit
	Specific Source:	Buses (diesel-powered)
Daytime hrs		
	Speed (mph)	20
	Avg. Number of Events/hr	12
Nighttime hrs		
	Speed (mph)	20
	Avg. Number of Events/hr	12
Distance	**Distance from Source to Receiver (ft)**	75
	Number of Intervening Rows of Buildings	0
Adjustments	**Noise Barrier?**	No

Noise Source Parameters		Source 2
	Source Type:	Highway/Transit
	Specific Source:	Buses (diesel-powered)
Daytime hrs		
	Speed (mph)	20
	Avg. Number of Events/hr	24
Nighttime hrs		
	Speed (mph)	
	Avg. Number of Events/hr	
Distance	**Distance from Source to Receiver (ft)**	75
	Number of Intervening Rows of Buildings	0
Adjustments	**Noise Barrier?**	No

Project Results Summary

Existing Ldn:	59 dBA
Total Project Ldn:	56 dBA
Total Noise Exposure:	61 dBA
Increase:	2 dB
Impact?:	None

Distance to Impact Contours

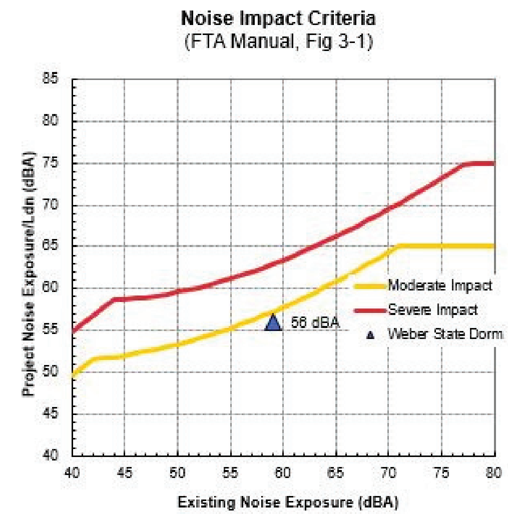
Dist to Mod. Impact Contour (Sources 1+2):	63 ft
Dist to Sev. Impact Contour (Sources 1+2):	26 ft

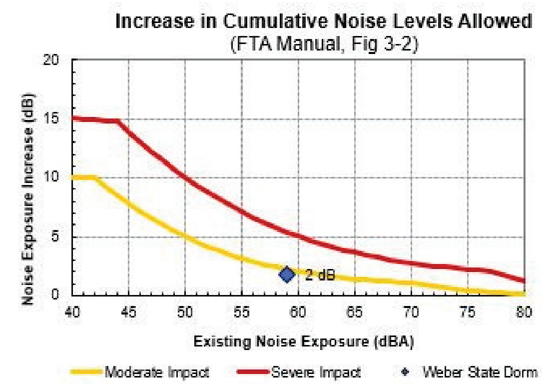
Source 1 Results

Leq(day):	48.6 dBA
Leq(night):	48.6 dBA
Ldn:	55.0 dBA

Source 2 Results

Leq(day):	51.6 dBA
Leq(night):	0.0 dBA
Ldn:	49.6 dBA
Incremental Ldn (Src 1-2):	56.1 dBA





Noise Impact Assessment Spreadsheet
Copyright 2007 HMMH Inc.
version: 7/3/2007

Project:	Residential

Receiver Parameters	
Receiver:	Residential
Land Use Category:	2. Residential
Existing Noise (Measured or Generic Value):	58 dBA

Noise Source Parameters	
Number of Noise Sources:	1

Noise Source Parameters		Source 1
	Source Type:	Highway/Transit
	Specific Source:	Buses (diesel-powered)
Daytime hrs	Speed (mph)	20
	Avg. Number of Events/hr	12
Nighttime hrs	Speed (mph)	20
	Avg. Number of Events/hr	12
Distance	Distance from Source to Receiver (ft)	75
	Number of Intervening Rows of Buildings	0
Adjustments	Noise Barrier?	No

Project Results Summary

Existing Ldn:	58 dBA
Total Project Ldn:	55 dBA
Total Noise Exposure:	60 dBA
Increase:	2 dB
Impact?:	None

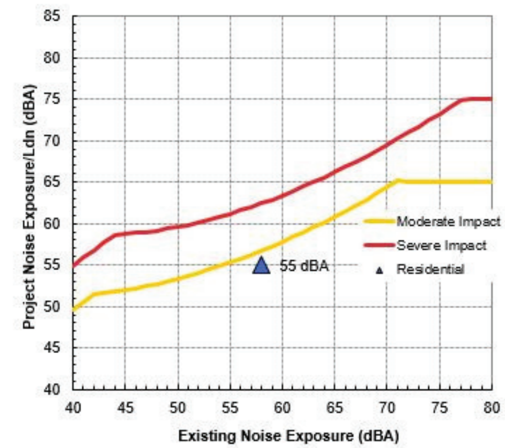
Distance to Impact Contours

Dist to Mod. Impact Contour (Source 1):	57 ft
Dist to Sev. Impact Contour (Source 1):	24 ft

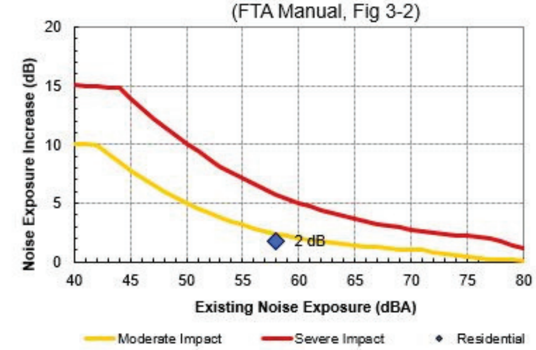
Source 1 Results

Leq(day):	48.6 dBA
Leq(night):	48.6 dBA
Ldn:	55.0 dBA

Noise Impact Criteria
(FTA Manual, Fig 3-1)



Increase in Cumulative Noise Levels Allowed
(FTA Manual, Fig 3-2)



Noise Impact Assessment Spreadsheet

version: 7/3/2007

Project:	McKay-Dee Hospital

Receiver Parameters	
Receiver:	Hospital Façade
Land Use Category:	2. Residential
Existing Noise (Measured or Generic Value):	59 dBA

Noise Source Parameters	
Number of Noise Sources:	1

Noise Source Parameters		Source 1
	Source Type:	Highway/Transit
	Specific Source:	Buses (diesel-powered)
Daytime hrs	Speed (mph)	20
	Avg. Number of Events/hr	12
Nighttime hrs	Speed (mph)	20
	Avg. Number of Events/hr	12
Distance	Distance from Source to Receiver (ft)	70
	Number of Intervening Rows of Buildings	0
Adjustments	Noise Barrier?	No

Project Results Summary

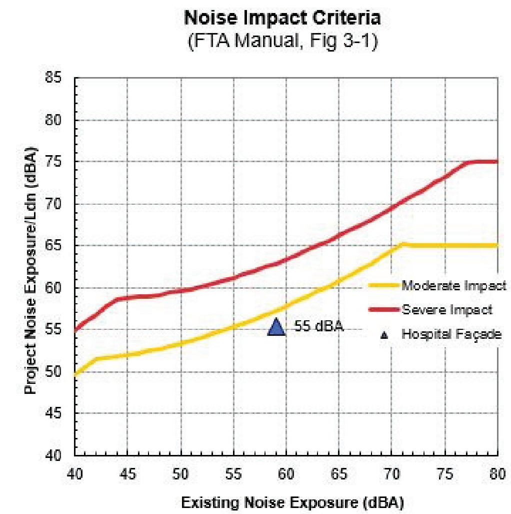
Existing Ldn:	59 dBA
Total Project Ldn:	55 dBA
Total Noise Exposure:	61 dBA
Increase:	2 dB
Impact?:	None

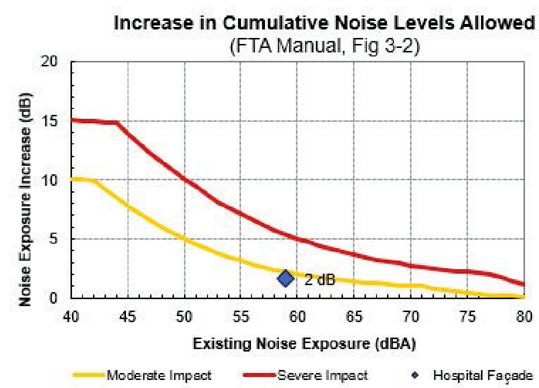
Distance to Impact Contours

Dist to Mod. Impact Contour (Source 1):	53 ft
Dist to Sev. Impact Contour (Source 1):	22 ft

Source 1 Results

Leq(day):	49.0 dBA
Leq(night):	49.0 dBA
Ldn:	55.4 dBA





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