

Community Noise Considerations

General

Large capacity, outdoor football stadiums have the potential to be significant noise sources. WJHW was requested to review the potential community sound impact for the proposed Colorado State University football stadium on the Main Campus. The goal of this analysis is to gain a pre-design understanding of the potential impact of stadium operations on nearby, sound sensitive properties. To perform this analysis we have reviewed potential sound levels associated with common stadium uses including football game and amplified music concerts.

Introduction and Assumptions

To predict sound levels at properties surrounding the proposed stadium, we have utilized the internationally recognized, Sound Plan software program. This software develops sound level contours based on user inputs including sound sources, sound levels, building construction, terrain, and prevailing weather conditions.

There are two potentially annoying sound sources at the stadium that may occur over an extended time period. These are the stadium or concert sound system and crowd noise. For the reasons outlined below, we have restricted our analysis to the sound system.

The process for developing the computer model includes:

- Determination of the location, quantity and directional characteristics of the sound sources. In this case the projected stadium PA system is assumed to be the primary sound source as discussed below. Our analysis of community sound impact includes both distributed sound system and end zone clusters designs used for sporting events along with a typical portable, concert sound system configuration
- The day-night average sound levels (DNL) which are based on a 24 hour time period have been predicted using an event time period, sporting or concert, beginning at 8:00pm and ending no later than 11:00pm. If an event were to be held earlier in the evening these results would be slightly lower. However, for the purpose of the study, 11:00pm has been chosen as the end time which is the latest a typical sporting or concert event would operate.
- A 3D model is created of the stadium structure, based on the current Populous design and site orientation.
- Buildings, terrain, and prevailing weather inputs are inserted as necessary to convey sound propagation through the community. Our modeling includes the proposed stadium construction, as noted above, but other community buildings are excluded. Due to the elevated position of the loudspeakers, houses and other buildings below three stories will not provide substantial “shadowing” of sound. Further, local terrain such as high hills and berms (the local terrain is relatively flat) and weather conditions (prevailing winds during football season are 5 mph or less) are not modeled as these will not substantially impact the noise propagation contours.
- The sound levels in the spectator seating area are set to a typical operating value, and the sound power levels of the sound sources (in the case the loudspeakers) are set to achieve that desired audience sound level.
- The results of the computer model are checked against known field data from similar conditions to verify the computer results are reasonable.

As with any simulation/model or computer calculation analysis, certain assumptions must be made about the conditions at the site. For the new stadium site, the following are the relevant assumptions that affect the calculated results.

- As noted above the primary sound source which impacts surrounding land uses for football games, sporting events and concerts is the permanent stadium or touring sound system. In addition, there may be special effects, such as the CSU celebratory cannon. It is our experience, based on many stadium and outdoor entertainment projects that amplified sound, both music and voice, is the primary source of community complaints, not crowd noise. This is due to the fact that the sound system is:
 - Operating a greater percentage of the duration of the event/game than are the special effects or crowd noise. The latter two are typically associated with home scoring and exciting plays/events, respectively.
 - The sound system on average is louder than crowd noise. While crowd noise can exceed the level of the sound system, as measured in the stadium, these occurrences are rare. In addition, the levels created by the crowd are due to literally thousands of relatively small sound sources, rather than single louder sources such as the sound system loudspeakers or the cannon. As the crowd sources are individually lower in acoustical energy and they are not perfectly in synchronization, crowd sound tends to travel a shorter distance than does sound from other sources with the same level inside the stadium.
 - The sound system can convey intelligible information, rhythmic content, etc. that makes it easier to distinguish from other normal, environmental noises, such as traffic, power and building mechanical equipment.
- The stadium sound system is currently planned to be a distributed type, rather than the more common (for collegiate stadiums) single point or end zone located cluster. The end zone cluster, as at Hughes Stadium, places a large array of loudspeakers in a single location to direct sound to the seating areas. In order to achieve the desired sound level at the far end zone, the sound power levels must be higher at the cluster, as sound travels approximately 500-800 ft. to the far end of the stadium. By comparison, the distributed speaker system places many, smaller speakers, typically on structure at the top of the seating bowl and on the face of the seating risers to project sound to the seating below. As the distance each speaker must project sound is much shorter than the end zone to end zone “throw” of the single point cluster, the sound power level is lower and, as with the crowd sound, the distance the sound travels is shorter. Distributed sound systems have been demonstrated at many stadiums to have a smaller community sound “footprint” than end zone clusters
- Sound levels in the seating areas are set to common observed levels for similar venues. PA system sound levels in collegiate football stadiums typically run from 85 dBA to as high as over 100 dBA, for very high powered sound systems in stadiums that operate their systems at high levels. Even in extreme circumstances, the sound levels are at their maximum only a brief time during an event (i.e. the sound system is not used continuously, but rather only during brief announcement periods). Based on sound level data from Hughes Stadium, provided to us by the University, we have assumed a maximum sound level in the seating bowl of the new stadium of 95 dBA. It must be remembered, however, that the average

level of the system is lower than the maximum and while the system is used frequently during a football game, its use, unlike a musical concert, is not continuous.

- As noted above, we have used the current stadium architectural design developed by Populous for the analysis. The stadium architectural configuration is important, as the stadium structure can provide barriers to sound. In the case of the concept design, the upper level seating does not extend around the entire perimeter of the field, which means the barriers provided by the stadium are not uniform in all directions. Currently, the fully “open” end of the stadium faces north towards the campus with the Scoreboard located at the South endzone, providing a level of noise mitigation to surrounding, non-University properties.

Results

The Sound Plan computer model depicts community sound levels as contours, with each line representing a different dBA sound level. The graphic output is very similar to a terrain topographical map, except the contour lines represent changes in sound level rather than changes in elevation.

As can be seen in the attached sound contour map, football game sound system (i.e. distributed configuration) maximum sound levels on the campus are as high 80-85 dBA, due north of the proposed stadium. The levels to the north are higher due to the “horseshoe” shape of the stadium seating sections, which do not offer as large a barrier as seen on the sideline structures and the scoreboard on the south end. Note that these sound levels are “worst case” and sound is not expected to be at this level for the entire event. There will be periods when no sound is played and periods where the sound system operates at a lower level.

The site is adjacent to a residential neighborhood, directly to the south. Projected sound levels in this residential neighborhood are as high as 70-75 dBA in limited areas. These levels are similar to the sound levels measured at adjacent, non-campus areas for Hughes Stadium, based on Hughes Stadium sound level data provided to us by the University.

Sound levels to the east and west of the stadium have projected sound levels of 65 dBA or less. This is due to the upper bowl of the stadium shielding more sound than the end zones.

The predicted sound levels for football game are considered to be maximum sound level and other sporting events (e.g. soccer games) will result in lower overall sound levels due to smaller crowd size, and, therefore, lower sound level requirements for PA system. Further, the intermittent use of the sound system means the sound levels shown are not continuous, but rather only constituting a fraction of the total game time use. As such, the community should not anticipate these sound levels being consistent throughout the day/time established for these events.

The Stadium concert configuration has the stage end set at the south end of the stadium with speakers pointed north, towards the campus. As concert speakers are typically deployed at a lower elevation than a permanent speaker clusters (such as on top of a scoreboard assembly as with the existing stadium), the barrier of the stadium structure does provide some beneficial mitigation. Sound levels to the north (on campus) are predicted to be between 80-85 dBA. To the west and south, sound levels are predicted to be 75 dBA or lower. Residential areas to the east are predicted to have sound levels between 65-70 dBA.

Based on the predicted sound levels, we have attempted to predict interior sound levels at residential properties based on typical residential construction. Given the approximate year of residential development, we assume the buildings will provide, on average, a 22 dBA reduction

from exterior sound sources to interior spaces of the residences with windows closed. Using this average, we could expect “peak” interior sound levels from football games (distributed sound source) to be approximately 43-48 dBA in limited residential areas directly to the south of the stadium. To the east and west of the stadium, interior “peak” sound levels inside the residences are expected to be approximately 43 dBA or less.

Concert sound is expected to result in interior sound levels of 53 dBA or lower to residences on the south and west sides of the stadium and 43-48 dBA to the east.

Analysis

There are several measures of community impact due to sound. These can include mere audibility, compliance with applicable standards (e.g. community noise ordinances) and subjective annoyance. In general, complaint frequency is more associated with annoyance than absolute level, although there is a strong correlation with higher sound levels resulting in more complaints. This relationship is affected by the nature of the noise source (ie; type of sound, the listener’s determination of the appropriateness of the sound), time of day, and frequency of events.

One objective standard of significance is compliance with applicable regulations. In the case of CSU, our understanding is the University, as a state institution, is not subject to the regulations of the City of Ft. Collins, Colorado; however the University has indicated they are committed to being a good neighbor and will pursue policies that are to the benefit of City residents.

For purposes of comparison, the City of Ft. Collins code lists allowable sound level limits of 55 dBA between 7 am and 8 pm (“day”) and 50 dBA after 8 pm (“night”) for residential areas as measured at the residential property line. Some downtown zones and commercial areas are listed at 60 dBA daytime and 55 dBA at night. Nighttime limits are often lower due to the perceived annoyance of sound late at night when residents may be sleeping, watching TV, etc. and the ambient sound levels in the community are lower, making other sounds more noticeable. The ambient levels in the areas surrounding the stadium site are dense enough that existing, evening ambient sound levels can be expected to be in excess of 50 dBA.

In addition to City regulations, another comparative metric for community sound impact assessment is HUD (the US Department of Housing and Urban Development) guidelines for residential development, which is based on the 24 hour, day-night average sound levels (DNL). This metric establishes an average noise level over a 24-hour period to assess noise exposure from intermittent community noise sources, with a 10 dB ‘penalty’ applied to nighttime (10 pm - 7 am) noise levels. For HUD compliance, the DNL at a residential property cannot exceed 75 dBA. Our analysis shows the 24-hour DNL for sporting events to not exceed 65 dBA. Interior DNL sound levels are below the HUD interior standard of DNL 45. For concerts, the 24-hour DNL is as high as 70 dBA at a very limited residential area to the south of the stadium.

Clearly, the sound level calculations, based on the assumptions discussed above and the concept stadium design exceed the City regulations as is currently the case at Hughes stadium. However, the daily noise exposure (DNL) does not exceed HUD standards. As the proposed stadium and its sound levels would be new to an established neighborhood, the University can expect objections to the development on the basis of sound levels and complaints during the first season or two of operation until the facility becomes an accepted part of city life.

While CSU may not be subject to the City noise regulations, the ordinance does allow for variances for sound sources. Given this recognition that there may be situations where sound levels that exceed the maximums may be acceptable, and given University’s desire to be a good neighbor,

there are several mitigation measures that can be considered for the project to allow it to be more compatible with the existing residential areas.

- **Number of Events** – By nature, a football stadium is a limited use facility – sporting events (e.g. football, soccer, and lacrosse) and concerts being the most common uses. The number of events held in the seating bowl is a factor in a community response. CSU can consider limiting the total number of events held in any calendar year. At this time, we understand there to be a maximum of eight football games per year and as many as 12 soccer games, with up to 9 lacrosse games. The calculation of events per year should also include other CSU events, graduations, high school games, marching band competitions, etc. that may be regular occurrences. Amplified music concerts are a separate category and are discussed below.
- **Time of Day/Day of Week** – Night events, especially those that continue past 11 pm are typically considered to have greater impact than daytime events. CSU can consider limiting the number of nighttime events in any year. Further, the day of week the event takes place can also impact the perceived community impact. Day time sporting events during the work week may not have as great an impact on the residences as many people are out of the house, at work or running errands, during these times. Weekend events, however, may be perceived as more annoying due to residential uses (e.g. barbecues, family gatherings, etc.) which may take place in the residential areas.
- **Concerts** – Amplified music concerts have the potential for higher peak and average sound levels than sports events, resulting in more complaints. CSU can consider the following measures:
 - Limit the total number of concerts per year.
 - Establish a time certain conclusion for concerts. This allows residents to be assured of the end of an event and has been shown to significantly reduce community response.
 - If concerts are not an important part of stadium operations, consider agreeing to hold concerts only on the granting of a special use permit (allowed by the ordinance) from the City as a prerequisite for holding a concert. This would show cooperation with the City, but may allow the City to prohibit concerts in the future, in response to complaints, depending on any agreements in place.

Summary

The perceived annoyance of stadium sound levels is dependent on numerous factors related to the use of the facility. It has been shown the maximum predicted noise levels from the stadium and touring sound systems will likely exceed the City of Ft. Collins noise ordinance based on typical uses and sound levels. However, CSU is not explicitly held to the City regulations. Rather, as part of the Universities “good neighbor” policy, there are some steps that can be taken to limit sound impact on the surrounding community.

We reiterate the sound levels predicted for sporting events at the stadium are maximum values and that these expected levels are intermittent. The overall average sound level will be lower, in general, due to the non-continuous use of the sound system during these periods.

Interior noise levels at houses are predicted to be lower than the levels shown in the sound contours. Based on average sound level reduction provided by residential construction, we could expect maximum interior sound levels to be 43-48 dBA in residences immediately south of the

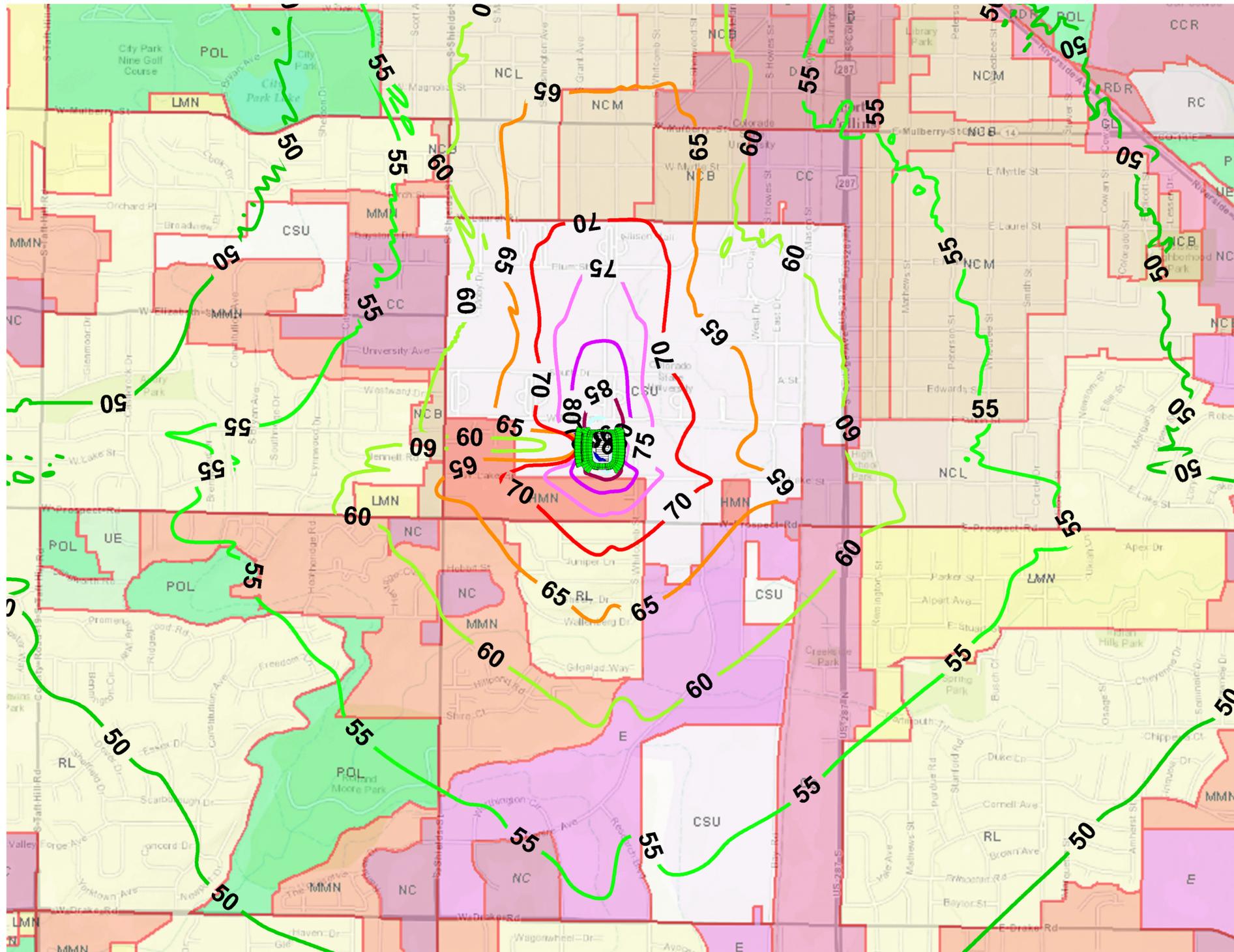
stadium (sporting events) or 53 dBA or lower at residences to the west and south (concerts). Residential areas further from the stadium or in areas more shielded from loudspeaker sound, we could expect interior sound levels to not exceed 43 dBA. While still audible in particularly quiet residences, these sound levels will typically fall below ambient sound levels from air condition, television, or other common household sound levels.

END OF ANALYSIS

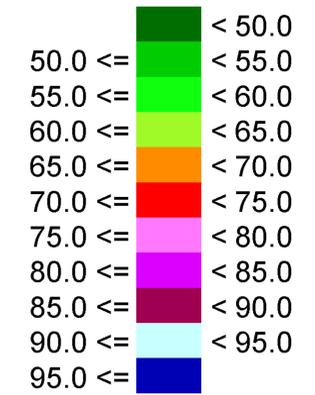
Colorado State University - New Football Stadium Fort Collins, CO

Predicted Noise Levels
Combination of Line Arrays at South End of Stadium & Distributed Fill Speakers

Sporting Event: Endzone Sound System In-Game Prediction



Noise Levels (dBA)



Signs and symbols

- Speakers
- Playing Field
- Seating Decks
- University Property

Length Scale = 1:600



27 June 2014

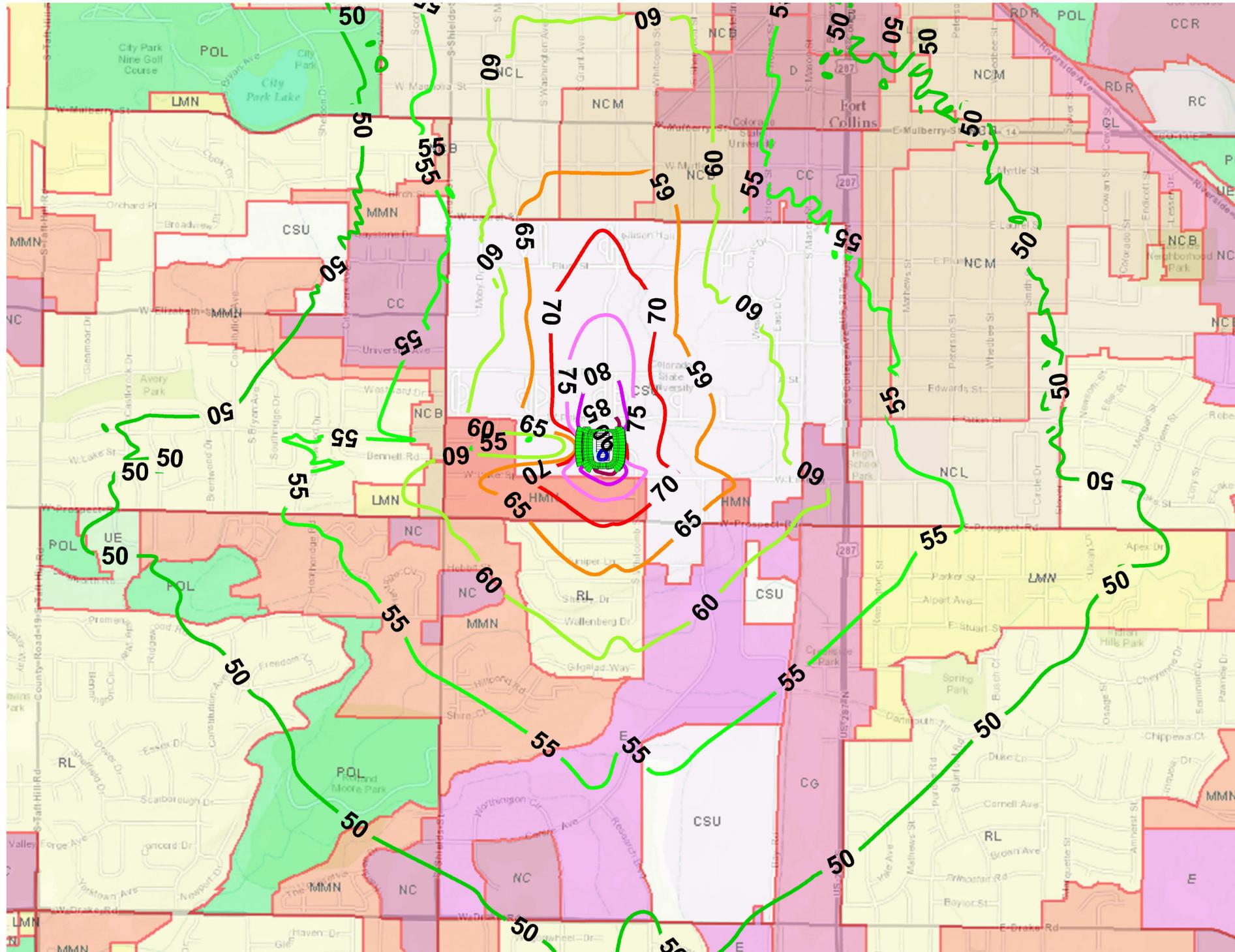
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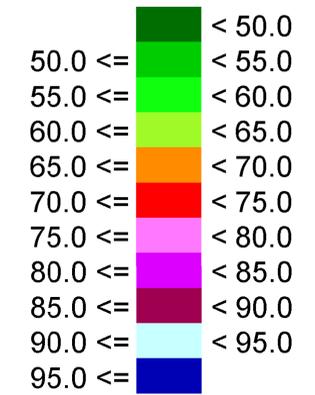
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Predicted Noise Levels - DNL
Combination of Line Arrays at South End of Stadium & Distributed Fill Speakers
Sporting Event from 8 pm to 11 pm

Sporting Event: Endzone Sound System 24 Hour DNL (Average) Prediction



Noise Levels (dBA)



Signs and symbols

- Speakers
- Playing Field
- Seating Decks
- University Property

Length Scale = 1:600



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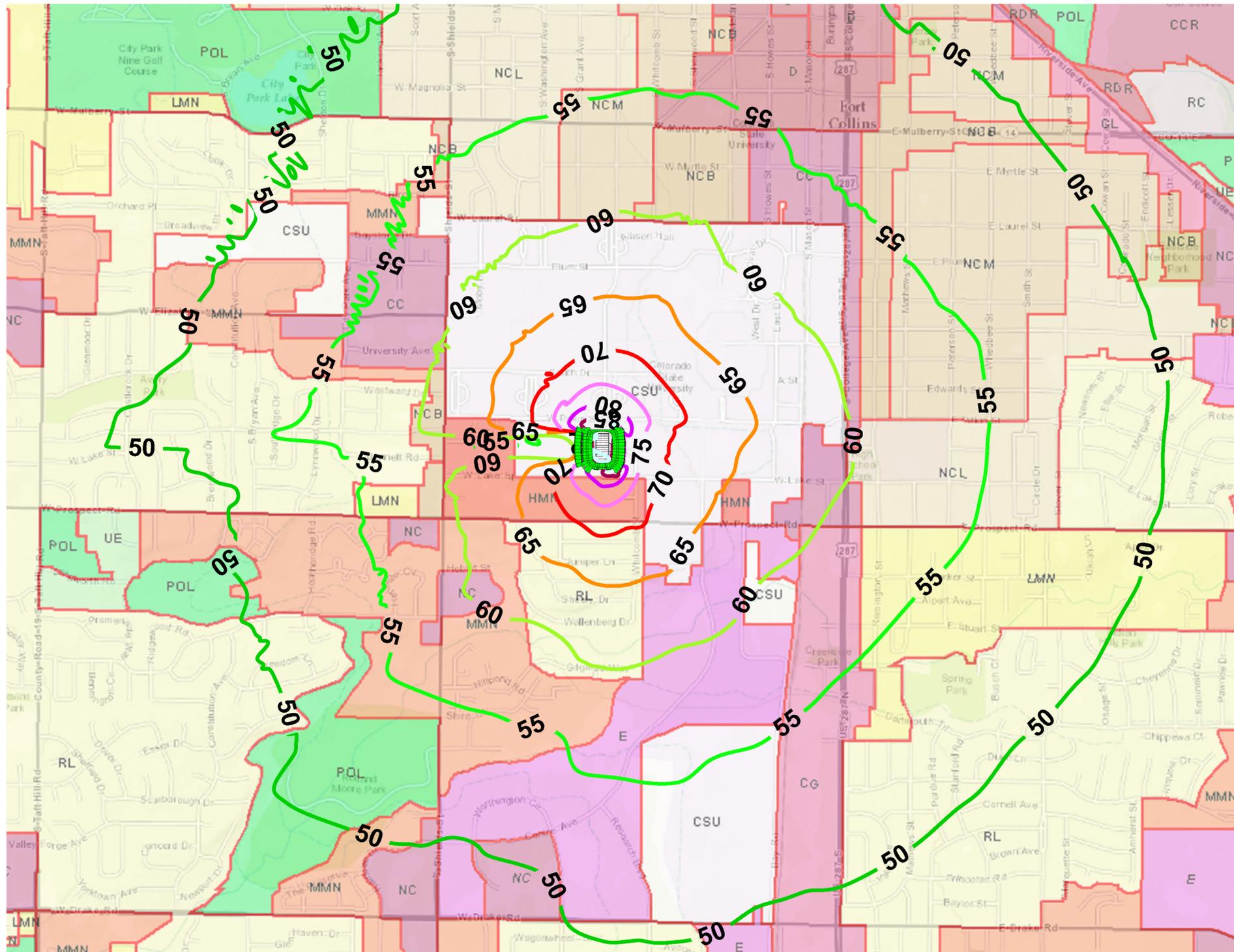
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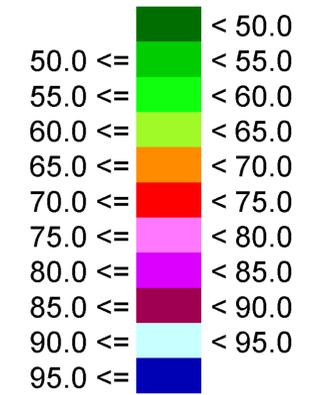
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Predicted Noise Levels
Distributed Speaker System

Sporting Event: Distributed Sound System In-Game Sporting Event Prediction



Noise Levels (dBA)



Signs and symbols

- Speakers
- Playing Field
- Seating Decks
- University Property

Length Scale = 1:600



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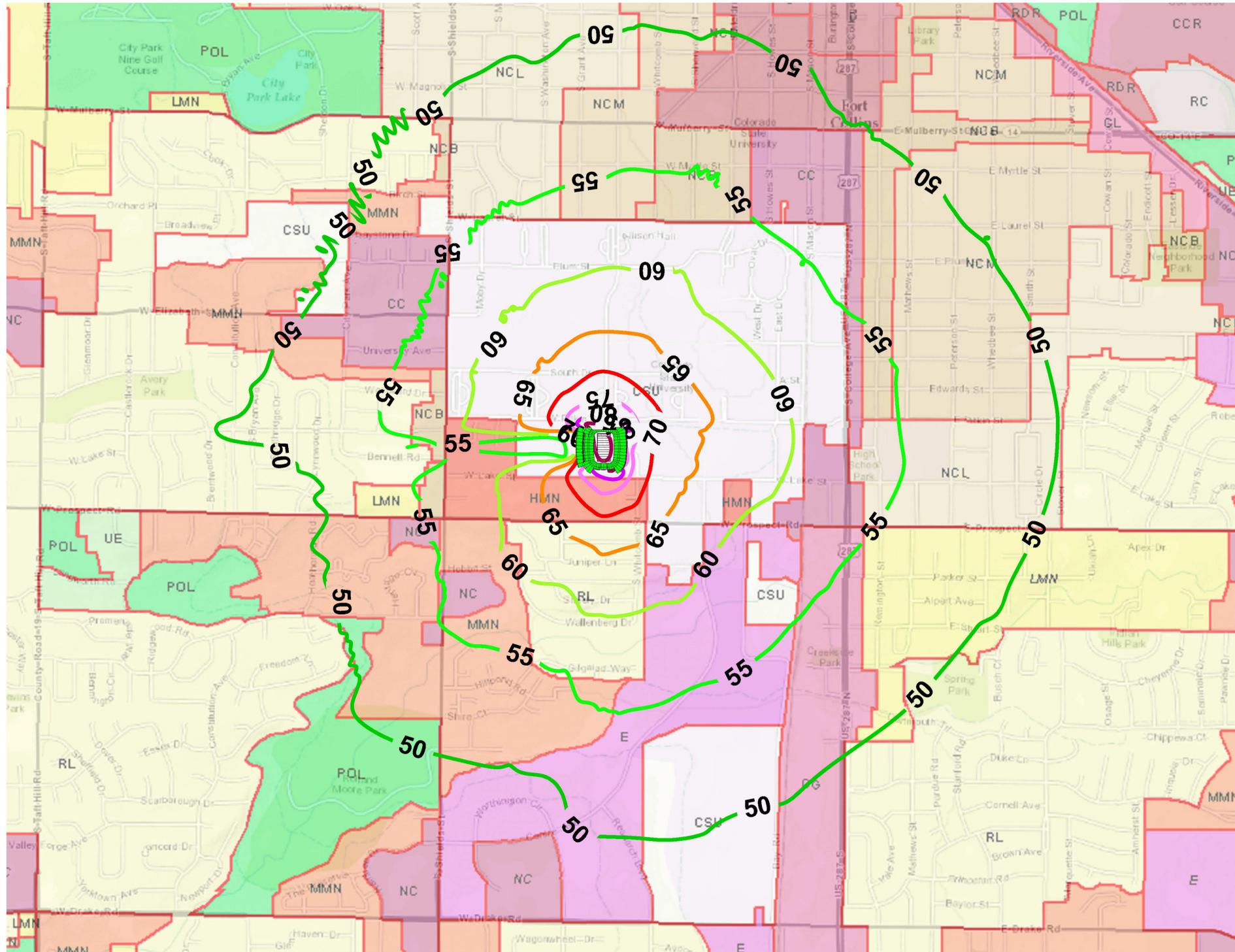
Colorado State University - New Football Stadium

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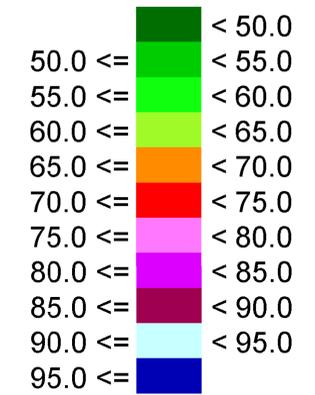
Predicted Noise Levels - DNL
 Distributed Speaker System
 Sporting Event from 8 pm to 11 pm

Sporting Event: Distributed Sound System

24 Hour DNL (Average) Prediction



Noise Levels (dBA)



Signs and symbols

- Speakers
- Playing Field
- Seating Decks
- University Property

Length Scale = 1:600



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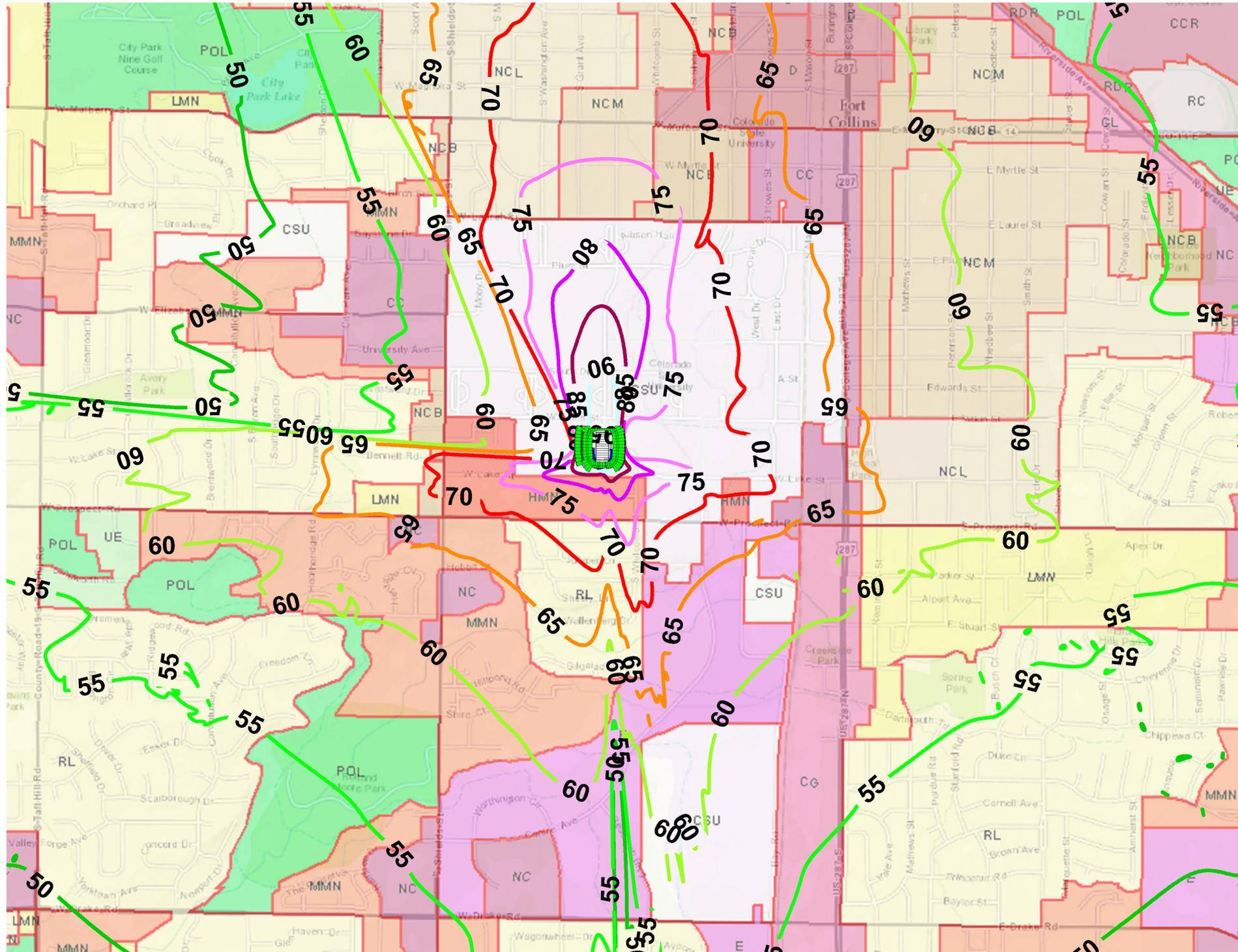
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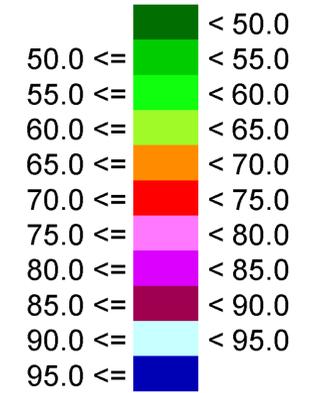
Colorado State University - New Football Stadium Fort Collins, CO

Predicted Noise Levels
Line Arrays at South End of Stadium

Concert: South Stage Facing North Event Prediction



Noise Levels (dBA)



Signs and symbols

- Speakers
- Playing Field
- Seating Decks
- University Property

Length Scale = 1:600



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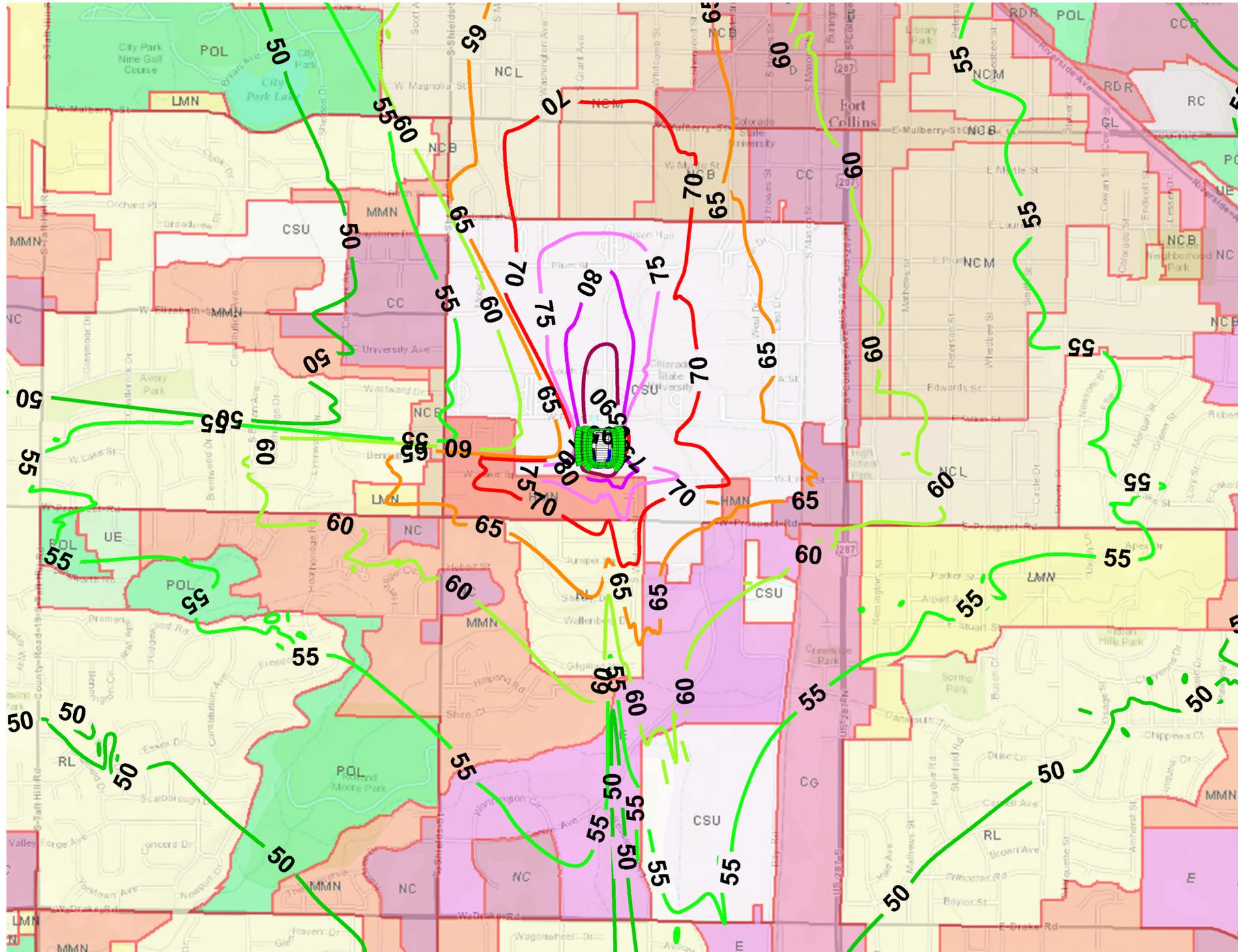
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f: 972-934-3720



Colorado State University - New Football Stadium Fort Collins, CO

Predicted Noise Levels - DNL
Line Arrays at South End of Stadium
Concert (Pop Music) from 8 pm - 11 pm

Concert: South Stage Facing North 24 Hour DNL (Average) Prediction



Noise Levels (dBA)

< 50.0
50.0 <=
55.0 <=
60.0 <=
65.0 <=
70.0 <=
75.0 <=
80.0 <=
85.0 <=
90.0 <=
95.0 <=

Signs and symbols

- Speakers
- Playing Field
- Seating Decks
- University Property

Length Scale = 1:600



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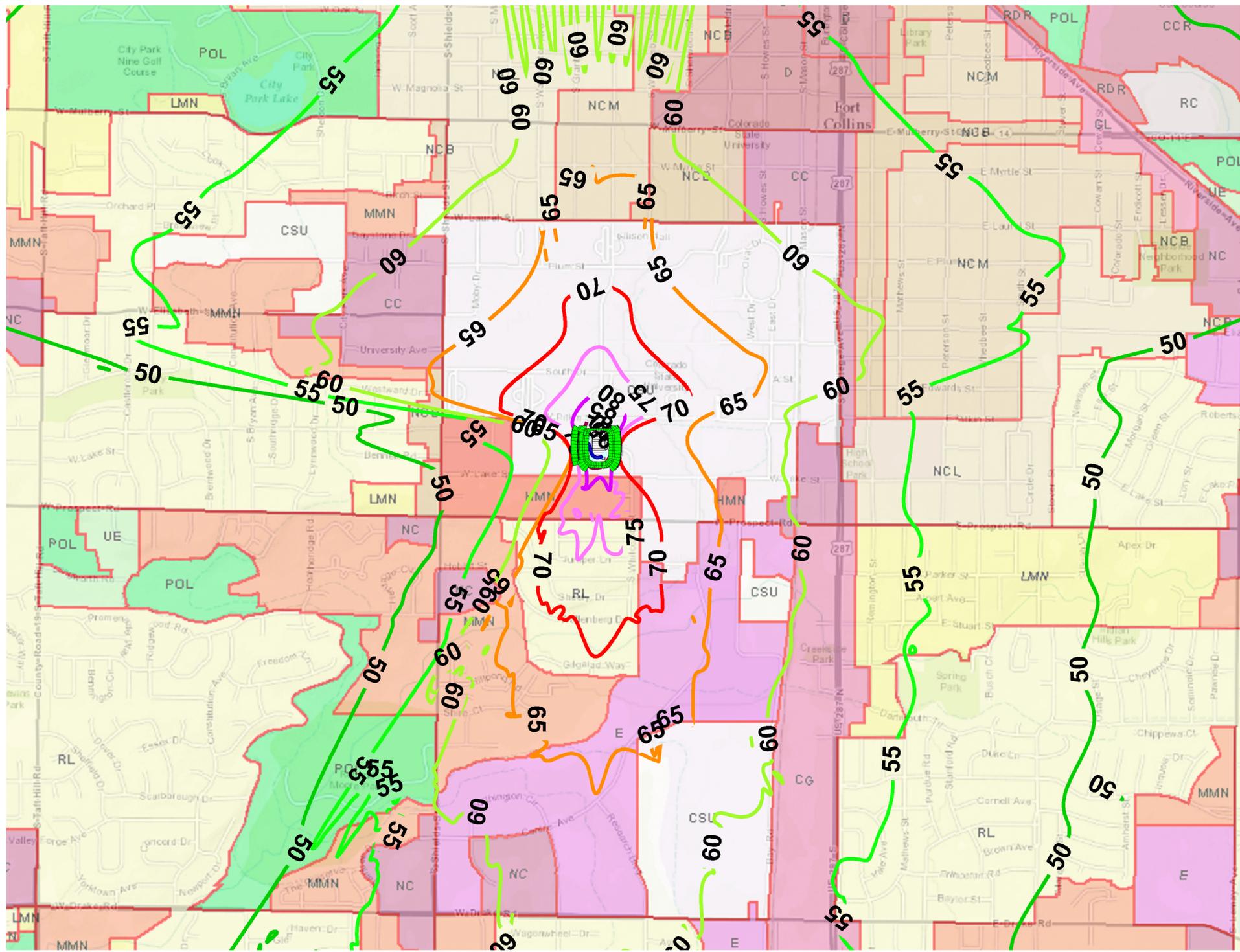
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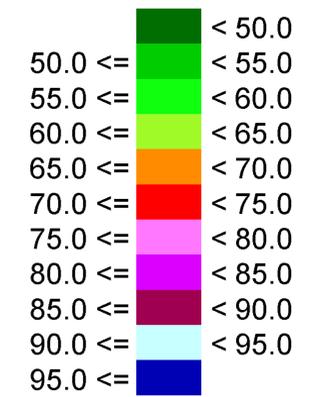
Colorado State University - New Football Stadium Fort Collins, CO

Predicted Noise Levels - DNL
Line Arrays at North End of Stadium
Concert (Pop Music) from 8 pm to 11 pm

Concert: North Stage Facing South 24 Hour DNL (Average) Prediction



Noise Levels (dBA)



Signs and symbols

- Speakers
- Playing Field
- Seating Decks
- University Property

Length Scale = 1:600



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Dallas, TX 75244
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