ARIZONA MILEPOST

YOUR LOCAL TECHNICAL ASSISTANCE PROGRAM

Spring 2003, Vol. 3 No. 2

SOUND BARRIERS AND NOISE CONTROL

INSIDE

Does Traffic Noise Affect the Quality of Your Life?

In many major urban areas noise is becoming one of the more important aspects of transportation and of the community itself. People are realizing the impact of noise on the quality of their life. In the past decade, noise has become an ever-increasing environmental pollution that affects peoples' health, comfort and general well being. Noise is something that is almost impossible to escape, whether it is during daytime or nighttime hours. It affects most of our lives in one form or another. As communities expand and increase in traffic, noise becomes an unwanted by-product of the times. It's one of the prices for progress! Or is it?

Old News or New News?

Noise pollution is not a new issue. It has been around since the beginning of transportation, and its roots closely parallel that of transportation development. The invention of the wheel is often credited to around 5,000 BC in Mesopotamia. This provided a major break through in the movement of goods and people as loads were no longer constrained to just what a human or animal could carry or drag. Although it is not known whether it applied just to transportation or not, by 4,000 BC, excessive noise was a punishable offense in Mesopotamia. So even as far back as 6,000 years ago, communities recognized the importance of noise on the quality of life.

As transportation progressed, iron "tyres" were developed around 800 BC. The origin of the term tyre (i.e. tire), by the way, refers to the iron rim around a wooden wheel, not the pneumatic tire we associate it with today. While making the tire much more durable and efficient, this invention created the first serious noise source. Previously, animal hooves and people were the primary noise sources. Now a more efficient noise generator had been invented. Namely, the clickety clank of iron wheels on cobblestone and block roads.

This problem no doubt helped produce the first documented noise regulation. In 44 BC Julius Caesar declared: "Hence-forward, no wheeled vehicle whatsoever will be allowed within the precincts of the city, from sunrise until the hour before dusk….Those which shall have entered during the night, and are still within the city at dawn, must halt and stand empty until the appointed hour".

It may not be known why Caesar preferred noise at night instead of during daytime, but it most assuredly led to the reason why Roman author Martial wrote “the noise on the streets at night sounded as if the whole of Rome was traveling through my bedroom”.

Almost two thousand years later the problem still existed. In 1869 a similar noise issue regarding wagons traveling over granite blocks was reported in London. The British Physician, Sir Norman Moore wrote: “Most of the streets were paved with granite sets(blocks) and on them the wagons with iron-tyred wheels made a din that prevented conversation while they passed by. The roar of London by day was almost terrible – a never varying deep rumble that made a background to all other sounds”.

Pavement Surface Type as the First Noise Mitigation Strategy

For the first several thousands years in the history of transportation, manmade roadways consisted of cobblestone and stone block construction. This technology dates back to about 4000 BC in Ur in the Middle East. In fact, with the decline of the Roman Empire around 450 AD, the art of road building was essentially lost until the late 1700s and early 1800s. Around 1820, a Scotsman named John McAdam developed an improved roadway design called macadam. This roadway design consisted of an eight-inch thick layer of three-inch aggregate followed by a two-inch thick layer of three quarter inch aggregate. This new design allowed highway speeds (up to 9 mph) to be dictated by the vehicle(wagon) instead of the roadway for the first time. This design became popular in the US for rural road construction during the 1830s and 40s.

As US cities became more modernized they reverted to the use of block and brick street construction similar to what existed in Europe. And, similar to what was previously reported by the British Physician in London, major US communities began experiencing similar noise issues. This led most major US cities during the 1870s to start using wooden blocks in lieu of granite blocks for roadway construction. Although wooden blocks were first used in Russia in the 14th century, their re-emergence provided a welcome relief from the clickety clank of the wagons and the pounding of the horseshoes. During the late 1800s wooden blocks saw wide spread use in major cities as a quiet pavement strategy.

Just how important the noise issue was during the late1800s is exemplified by the willingness of the communities to accept pavement service lives of half to one fourth of what could be obtained with granite block streets. Wooden blocks were considered to have an expected service life of only10 years while the granite blocks they were replacing had an expected life of 15-25 years under heavy traffic and 40-50 years under normal traffic.

During this same time period the use of mastic streets, consisting of native asphalt spread over a prepared base, was also becoming common and, like wooden blocks, this design produced quiet pavements. As is true today, each design had its strengths and weaknesses. Although mastic streets proved to be quiet, they had traction issues. In those days, this was related to the number of falls of horses. A study in the 1890s reported typical distances a horse could travel between falls. For sheet or mastic asphalt it was 220 km, for granite blocks 320 km, and for wood blocks, 550 km.

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On the other hand, wood blocks also had problems as was vividly recognized after the Chicago fire of 1871. That's right, Chicago had wooden streets.

Along with the advent of hot mix asphalt in the early 1900s came the development of motorized travel. So at about the same time that technology was beginning to allow a smoother, quieter roadway, technology was providing a nosier vehicle. However, instead of tires making the noise as with wagons, engines and exhausts were the new culprits. As the use of motorized vehicles became more common, noise levels increased.

As motorized transportation expanded during the 1900s noise problems continued un-abated until the early 1950s when US manufacturers imposed voluntary limitations on exhaust noise. This was followed by California noise legislation in the late 1960s and eventually Federal noise regulations in the early 1970s.

During the 1900s, except for isolated instances, pavement surface type was not used to control noise as was commonly done at the end of the 1800s. By the end of the 1900s, pavement surface type, could not be used for noise mitigation in the US for federally funded projects- quite a turn about in just one hundred years!

What is Noise and How is it Controlled?

The term noise refers to "unwanted sound". Different people have different perceptions of what sound they like and what sound they don't like. The roar of the crowd when the Diamond backs won the World Series or the laughter of children would commonly be considered pleasant sounds, while the sound of a lawnmower or garbage truck would be considered noise or unwanted sound.

Noise like all other sounds is a form of acoustic energy. It differs from pleasant sounds only in the fact that it often disturbs us and has the characteristics of an uninvited guest. To understand noise or sound, requires both an understanding of the physics of sound and how humans respond to it.

Sound is an acoustic energy that is measured in decibels. The decibel combines the magnitude of sound with how humans hear. Since human hearing covers such a large range of sounds, it does not lend itself to be measured with a linear scale. If a linear scale was used to measure all sounds that could be heard by the human ear, most sounds (assuming a linear scale of 0 to 1) occurring in daily life would be recorded between 0.0 and 0.01. Thus, it would be difficult to discriminate between sound levels in our daily lives on a linear scale.

Instead of a linear scale, a logarithmic scale is used to represent sound levels and the unit is called a decibel or dB. The term dBA will most often be used and this refers to the loudness that a human ear would perceive. It, in affect, is a dB corrected to account for human hearing. The ear has its own filtering mechanisms and the inclusion of the A after dB indicates that the scale has been adjusted or "fine tuned" to hear like a human.

On a logarithmic scale a doubling of the sound is represented by a ten dBA increase. So anytime you see a sound ten dBA higher than another, its twice as loud. Similarly, if you combine two sounds of equal loudness you increase the total noise by only 3 dBA. A three dBA increase represents a change of 50%. This is how logarithms work.

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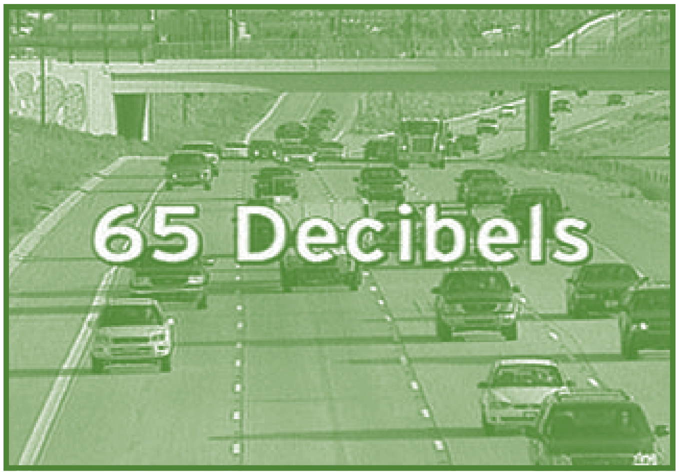
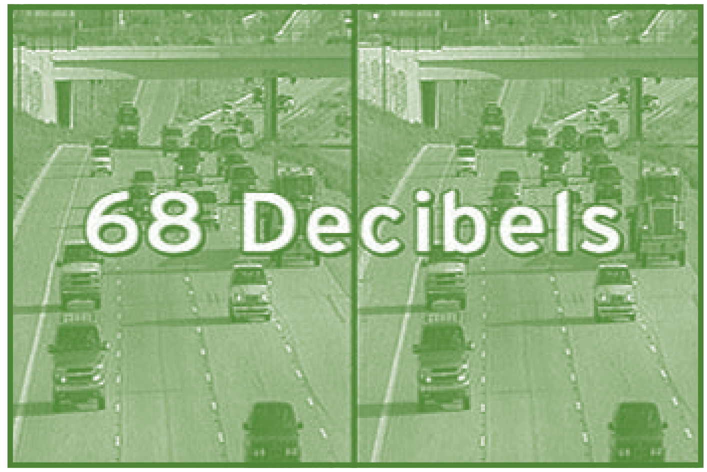


Represents Freeway Noise Level at 65 Decibels



Adding Two Noise Levels of 65dB each Results in a Total Noise Level of Only 68 dB

The decibel scale ranges from 0 dBA, the threshold of human hearing, to 140 dBA where serious hearing damage can occur. Table 1(page8) represents this scale and some of the levels associated with various daily activities. A serene setting might have a decibel level of 30 dBA while a peaceful subdivision might be at 40 to 50 dBA. Alongside a freeway the sound level (i.e. noise) might be in the range of 70 to 80 dBA. The transition from a peaceful environment to a noisy environment is around 50 to 70 dBA. Sustained exposure to noise levels in excess of 65 dBA can have health effects.

As a general rule of thumb, we can only discriminate between two sounds levels that are at least 3 dBA different in loudness. Values that are less than that oftentimes cannot be told apart. A healthy human ear, under ideal conditions can hear sounds at 1 dBA, but sounds at 1dBA and 3 dBA might be perceived as the same loudness.

In addition to sound level, people hear over a range of frequencies (and this is the reason for the A weighting described earlier). A person with good hearing can typically hear frequencies between 20 Hz and 20,000 Hz. An older person, however, may not be able to hear frequencies above 5,000 Hz. So this indicates, to some extent, some of the reasons why we all hear things somewhat differently.

In addition to the decibel, a useful measurement for assessing traffic noise is the Equivalent Sound Level or Leq. Leq is the energy-based average of the sound energy over time. It effectively represents all the sound observed over the specified time period with an average value for that time period. This allows for consistent comparisons from site to site.

How is Noise Controlled?

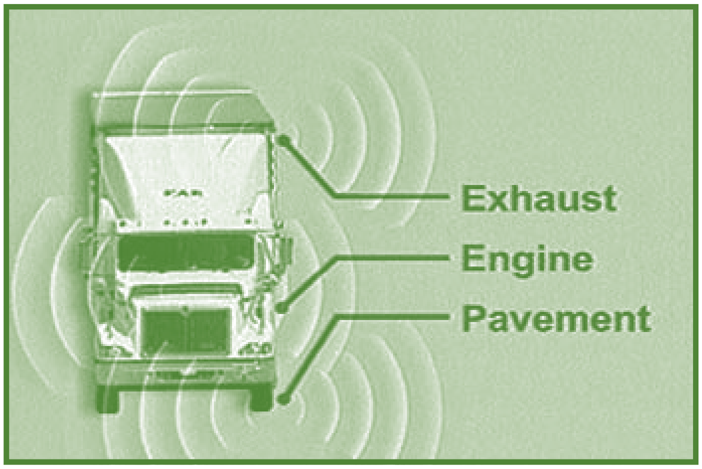
For highway purposes it is useful to think of noise in terms of a source, a path and a receiver. A typical source would be a passenger car or a truck. A path would be the area between the vehicles making noise and any location where noise is objectionable. The receiver is the facility or residence where noise is objectionable.

HOW IS NOISE CONTROLLED? - CONTINUED

Although trucks and cars are both sources of noise, they differ in how they create noise. Passenger cars, at highway speeds, typically produce noise predominantly from their tires. This results in a steady whine type noise. Trucks on the other hand, produce noise from their tires, exhaust, and engines. Since truck exhausts are elevated, this noise tends to travel farther. Although trucks are louder as sources, traffic that is comprised almost exclusively of cars can be more annoying due to the constant whine effect.

Definition of Source, Path, and Receiver

Noise Generation by Traffic

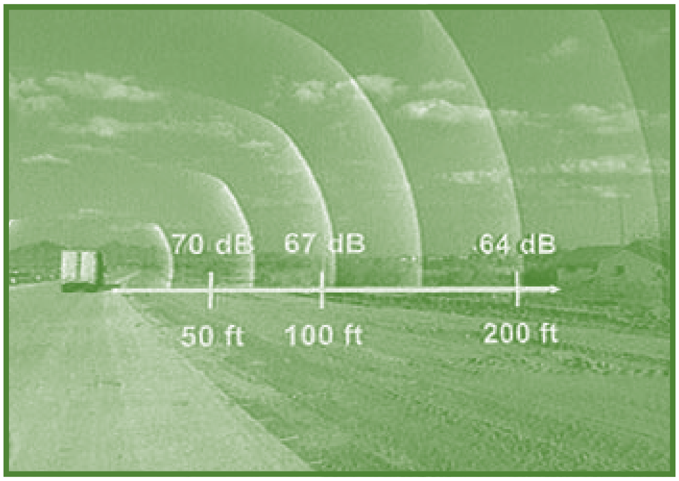


Trucks Can Generate Noise Differently than Cars

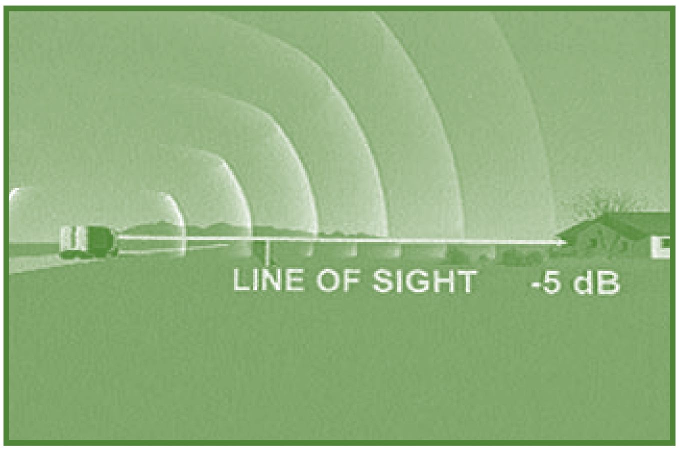
The path is where noise control is generally attempted. Noise control can occur along the path in two ways: through distance or by inserting an obstruction. Both methods reduce noise levels.

Distance is an effective noise control because geometric spreading reduces the level of sound. For a stationary single source of noise (aka, a point source), the noise expands in a bubble shape and at double the distance the noise level will decrease by 6 dBA. A stationary vehicle is a point source, but a vehicle in motion and bumper-to-bumper with other vehicles, behaves like an endless train and is viewed as a line source of noise. Line source noise expands in a cylindrical shape and will decrease 3 dBA each time the distance from the (line) source is doubled. For example, if the noise level from a stream of vehicles (a line source) at 50 ft the noise level was at 70 dBA, at 100 ft it would be at 67 dBA and at 200 ft it would be at 64 dBA. So if enough distance is possible, the noise will be less objectionable.

The second form of noise control consists of the use of walls or berms to intercept the noise. This forces sound waves to bend around them or diffract. This diffraction causes the sound waves to consume energy and thus reduces the sound level. To be effective, walls need to be at least as high as the line of sight to the facility—that is, block the view. Once the wall height is equal to an interception of the line of sight, a good rule of thumb is that it requires an additional 2 ft of wall height for each additional 1dB reduction in noise levels. For example, after a wall is placed to intercept the line of sight and the resultant noise level at the residence is 70 dBA, it would require an increase of approximately 6 ft of wall height to get the reading to 67 dBA.

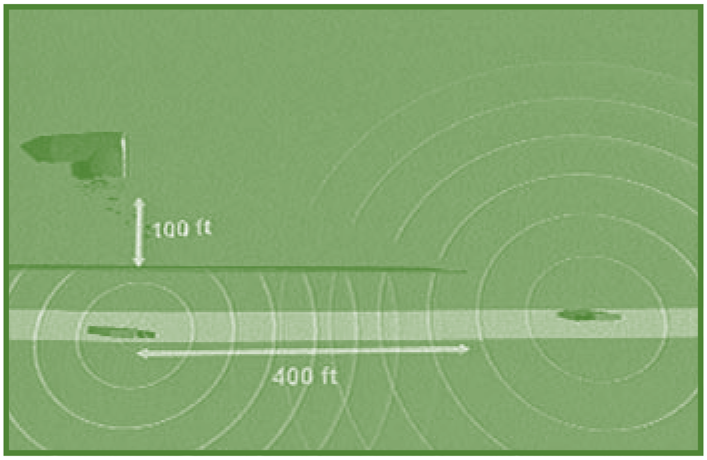


How Noise is Reduced Through Distance From a Line Source



Barriers Must Be At Least as High as the Line of Sight to the Receiver

Sound not only diffracts over the tops of walls it also diffracts around the ends of walls. This typically requires that the wall or berm to extend 400 ft beyond the last receptor for each one hundred feet behind the wall that it is situated. It is for this reason that walls are not effective on arterial streets for noise control due to the many driveways and side streets that would allow the noise to bend around the ends of walls.



Sound Diffracting Around the End of a Noise Wall

In Arizona, the three forms of noise control currently employed are walls, berms, and a combination of the two. Berms are an effective solution because they blend in with the surrounding area and will provide a slightly greater noise reduction than would a wall of the same height. However, berms require a lot of land to construct. To construct 10 ft of berm height requires 70 feet of horizontal distance. Noise walls typically range in height from 8 to 20 ft depending on what is needed to reduce the noise to an acceptable level. In Arizona, noise walls cost between $150 to $400 per lineal foot depending on height.

It is often hoped that vegetation will reduce noise levels. However, in the desert environment this is unlikely. Research has indicated that vegetation has to be dense, deep and tall to be effective. A rule of thumb is that a forest needs to be 100 ft deep to reduce noise levels by 5 dB.

What Levels Are Noise Mitigation Designed To?

Federal guidelines require mitigation levels to 67 dBA or less at the residence. In Arizona, the Department of Transportation (ADOT) designs to below 64 dBA. This is the lowest value used in the United States by state agencies and provides the quietest neighborhoods. ADOT also goes back for three years after construction to verify that the design values were obtained. If they are not met, additional mitigation measures are pursued such as increasing wall heights or lengths.

Pavement Surface Type as the Next Noise Mitigation Strategy

As previously mentioned, the use of pavement surface type as a noise mitigation strategy has not occurred in the US for almost a century. However, the ever-increasing pressure to improve the quality of life in urban areas by reducing traffic noise levels has resulted in renewed interest in this quiet pavement strategy. To address this, ADOT and the California DOT (Caltrans) have pursued noise research programs to investigate the use of pavement surface type as a noise mitigation strategy. ADOT and Caltrans have worked cooperatively in this effort.

Since enactment of federal legislation requiring noise mitigation for transportation facilities, pavement type has not been allowed as a noise mitigation strategy by the FHWA. This is due to the belief that pavement conditions change and noise characteristics are not permanent. And, since pavement conditions change, no consistent noise level value could be assumed over the pavement design period.

However, current research, by ADOT and Caltrans, indicates that the pavement properties can be managed, and that effective noise reductions can be obtained through the use of pavement surface selection. This resulted in the two states becoming pilot states for this issue.

In the Phoenix metropolitan area ADOT is currently planning on covering most of the PCCP using an Asphalt Rubber Asphalt Concrete Friction Course (AR-ACFC). This will occur over the next three years. Results to date have been well received by the community.

All Sound Barrier and Noise Control Articles were prepared By Larry Scofield, Arizona Department of Transportation (ADOT) and Bruce Rymer, California DOT (CALTRANS)

INDOOR AND OUR DOOR NOISE LEVELS

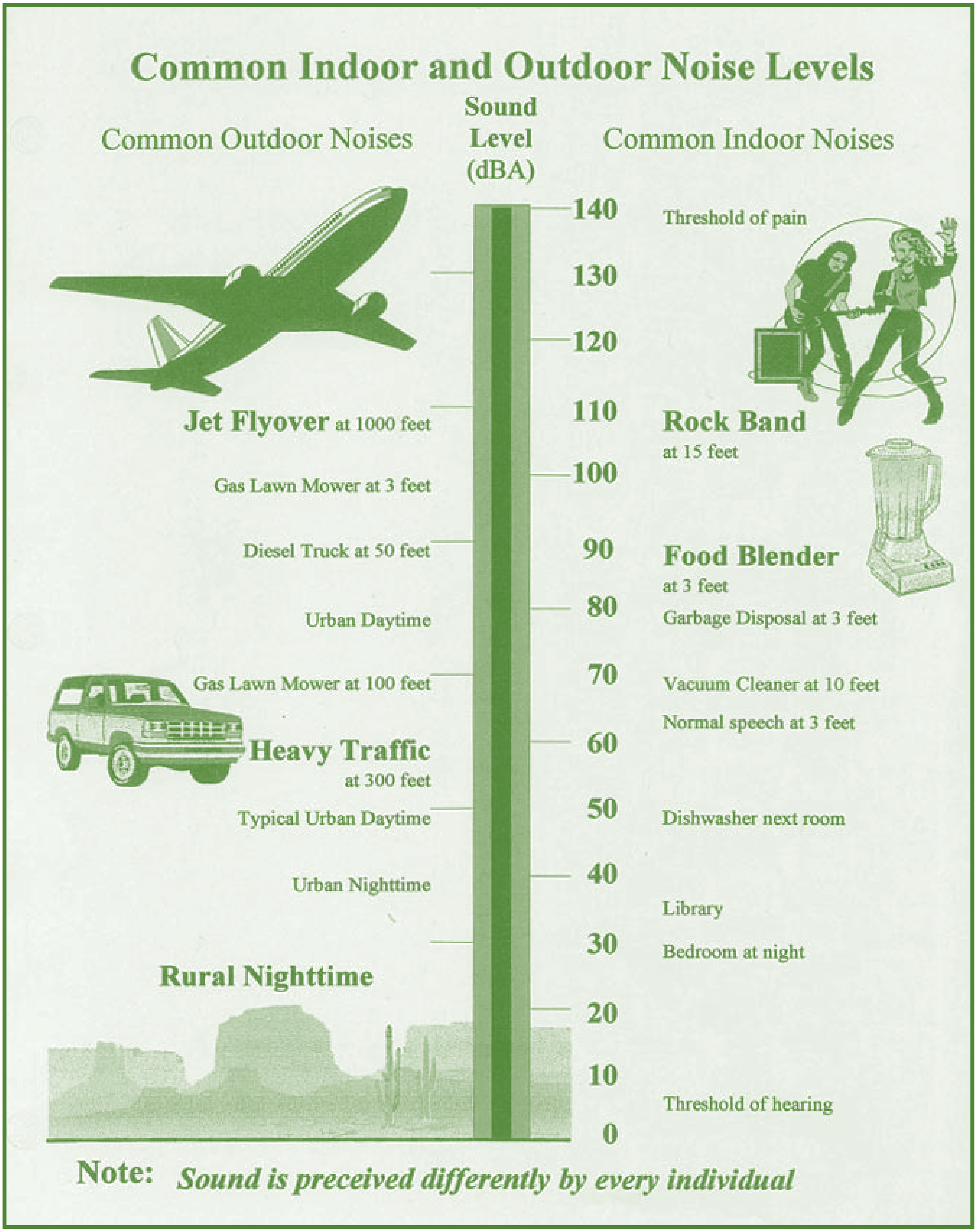


Table 1

CONGRATULATIONS! ROAD SCHOLAR GRADUATES

The AZ LTAP Center would like to take this opportunity to congratulate all of our Level I Road Scholar graduates. Their achievement represents a level of professionalism, and demonstrates their commitment to self-improvement and personal development. With their added knowledge, skills, and capabilities these Road Scholars can more effectively maintain and repair roads in their communities. It is hoped that the cities and towns they serve will also recognize their achievement.

City of Casa Grande
Pedro Apodaca, Robert Bartelson, Charles Bojoorquez
Bobby Costales, Orlando Gonzales, Chris Lawson
Todd Miller, David Rodriguez, Lonnie Sanders
Rojelio Sotelo, Francisco Velasco

Coconino County
Wes Beauchamp, Dennis Bracken,,Richard Canizales
Richard Cox, Jim Santiago Griego, Robert Kimball
Billy Lane, Danny Lann, Benny Lucero
John McKeever, Thomas Murphy, John Roberds
Greg Sanchez, Sam Strange, Jim Westra

City of Cottonwood
Claude Lankford, James Wixom

La Paz County
Kenneth Putman

Town of Marana
Deana Ellis, Myrlene Francis

Maricopa County
Katherine Baker, Mark Clark, Dan Clements
Ted Collins, Severiano Coronado, Armando DeLaRosa
Benjamin Dominguez, William Grimes, Scott Johnson
Michael Jones, Ron Juarez, Michael Messina
Jose Morales, James Newman, Ralph Peterson
Rudy Rios, David Ritzler, Julie Ruegsegger
Richard Steiner, Frank Urquiza, Frankie Valencia,
Soteno Max Zavala

Town of Parker
Dan Hiatt, Mike Lattin

Navajo County
George Amador, Bill Barnard, Cameron Crandell
Wade Ellison, Larry Fernau, Joy Halvorsen
Patrick Hancock, Tommy Hunt, Vernon Lewis
Bill Lucero, Marty McNeil, Jimmie Patterson
David Robinson, Brett Schmitt, Robert Smith
V. Pride Spurlock, Bill Sturgeon, Randall Whipple
Tracy Young

Pinal County
Linda Althoff, Ray Garcia, Brian McGinnis,
Thomas Miller, Charles Mitchell, Frank Reed
John Sharp, Gilbert Tarango, Dustin Wold

City of Safford
Martin Avillar, Bobby Chavez, Ublado Flores
MartinJurado, Art Mata, Marlin Martin
Jesus Mendez, Granger Moffet
Mike Mott, Don Oaks, Bill Peck,
Jose Romero, Arnold Sanchez

City of Sedona
Robert Larson

Show Low
John Barwicki, Phil Meyers, Chris Wade
Kennard Wilcock

If you work with or know any of the above graduates please join us in congratulating them on their achievement.

The Road Scholar Program is intended to serve Arizona municipalites. We welcome any suggestions for workshops and for Road Scholar improvement.

FHWA UNVEILS NEW WEB SITE

FHWA Unveils New Web Site to Help State, Local Agencies Manage Traffic Congestion

The U.S. Department of Transportation's Federal Highway Administration (FHWA announced a new Web site to provide state and local agencies simple access to a variety of tools and information on traffic congestion and to help them find solutions to traffic problems in their areas.

"Relieving traffic congestion is one of our top priorities," FHWA Administrator Mary E. Peters said. "We are working closely with state and local officials to develop and carry out a comprehensive set of solutions designed to help reduce traffic congestion nationwide. This includes providing them with valuable information that can help them manage traffic conditions in their areas."

The new "Congestion and Traffic" Web site – at www.fhwa.dot.gov/congestion – is part of the FHWA's efforts to help state and local transportation agencies develop initiatives to reduce congestion through effective system management and operations strategies.

A section on program tools offers specific information on the most prevalent causes of traffic congestion: traffic incidents and work zones. About half of all traffic congestion is caused by temporary disruptions such as traffic incidents and work zones, dramatically reducing the available capacity and reliability of the entire transportation system.

The agency developed the Congestion and Traffic Web site in response to the need on the part of state and local partners for technical guidance and best practices. The new site consolidates all the information found about traffic congestion on FHWA's Web site onto one portal, linking to the various FHWA programs and services designed to help mitigate congestion. It also links to specific state programs designed to manage congestion and to articles, research, and other information related to traffic conditions.

More information on traffic operations is available at www.ops.fhwa.dot.gov.

ACROSS THE USA AND IN YOUR NEIGHBORHOOD

Colorado: CDOT will install continuous shoulder rumble strips on interstate system statewide. In an effort to reduce run-off-the-road crashes in Colorado, CDOT has initiated a Statewide Rumble Strip project. The installation of shoulder rumble strips on 86 miles of I-25, 143 miles of I-70 and 61 miles of I-76 will result in continuous rumble strips on the Interstate System throughout the state (excluding the Denver Metro area). CDOT uses a bicycle-friendly rumble strip design that was adopted as a result of a study their Research Division completed in May 2001. The project will go to ad this month and all work will be complete by September 30, 2003.

Iowa: New Paved Shoulder Policy Adopted: The Iowa Department of Transportation has adopted a policy of providing four-foot paved shoulders on all state roadways that are part of the NHS system or have a traffic volume exceeding 3,000 vehicles a day. In addition, milled in rumble strips will be provided on interstates and expressways. One third of all fatalities in Iowa result from a single vehicle running off the road

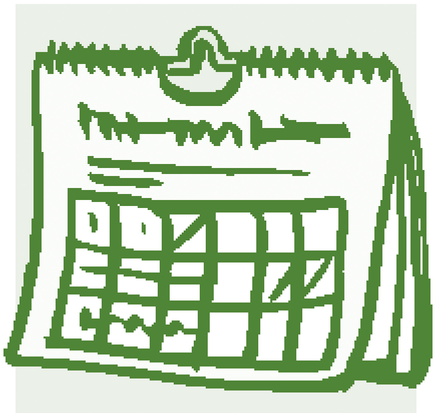
FLH: Hoover Dam Bypass, Arizona/Nevada: On January 8, the Central Federal Lands Highway Division awarded the first highway contract for the Hoover Dam Bypass. The 1.8 miles project will construct the **Arizona** approach and is the first of four major contracts anticipated to complete the project. Thirteen highly competitive bids were received with the low bid of $21.5 million awarded to a joint venture of R. E. Monks Construction and Vastco Inc. A+B bidding was utilized to reduce public impacts, administrative costs, and accelerate completion. The joint venture committed to completing the project in 620 days, 80 days less than estimated. Work is expected to begin in late January. Work on the Nevada Approach will begin in mid-2003 and Colorado River Bridge in late 2003. The entire Hoover Dam Bypass Project is expected to be complete in 2007 at a cost of $234 million.

CALENDAR OF EVENTS

April 1-3, 2003: Escambia County Pavement Preservation Program in Pensacola, FL

April 7-11, 2003: National Work Zone Awareness Week, CONTACT: American Traffic Safety Services Association, (540) 368-1701, general@atssa.com , <http://www.atssa.com> (Second week of April every year)

April 8, 2003: WASHTO-X Video Conferencing on Construction: QC/QA Practices. For more information http://www.washto-x.org



April 9, 2003 Click, Listen & Learn Selection of Consultants. For more information http://www.apwa.net/Education/CLL/April 29, 2003: Adjustable Manhole Covers in Logan, UT

April 16,17,18, 2003: Roads & Streets Conference Driving Our Future in Tucson, AZ. For more information http://www.acea.org/Coming.htm

April 22, 2003: WASHTO-X Video Conferencing on Context Sensitive Designs & Solutions. For more information http://www.washto-x.org

April 27-30, 2003: North American Snow Conference, QuebecCity, Quebec, Canada. CONTACT: American Public Works Association, (816) 472-6100, apwa@apwa.net, http://www.apwa.net (LTAP Exhibit)

April 29, 2003: Adjustable Manhole Covers, Logan, UT. CONTACT: Product Demonstration Showcase Program, (352) 392-2371 ext. 223, http://www.pdshowcase.org

May 1-2, 2003: AACE Spring meeting with AFMA at the Radison Poco Diablo Resort I Sedona, AZ. For more information http://www.azace.org/2002mtgs.htm

May 13, 2003: WASHTO-X Video Conferencing on Work Zone Traffic Control & Safety. For more information http://www.washto-x.org

May 16-21, 2003: ASTD International Conference and Exposition, San Diego, CA. CONTACT: American Society for Training and Development, (703) 683-8100, (800) 628-2783, info@astd.org, http://www.astd.org

May 18-24, 2003: National Public Works Week, CONTACT: American Public Works Association, (816) 472-6100, apwa@apwa.net, <http://www.apwa.net>

May 22, 2003: Click, Listen & Learn Managing the Public Response- How to Keep Your Foot Out of Your Month. For more information http://www.apwa.net/Education/CLL/

May 27, 2003: WASHTO-X Video Conferencing on Planning & Programming: Incorporating Operations in the Process. For more information http://www.washto-x.org

June 18, 2003: Click, Listen & Learn Where Does Public Works Fit into Smart Growth Planning? For more information http://www.apwa.net/Education/CLL/

June 22, 2003: International Conference on Low Volume Roads, Reno, NV. CONTACT: Transportation Research Board, (202) 334-2934, http://www.trb.org/

June 25, 2003: WASHTO-X Video Conferencing on Highway Noise Abatement. For information http://www.washto-x.org

CENTER NEWS!

AZ LTAP has established a new electronic mailing information process. A weekly update will be e-mailed to representatives within local transportation agencies and consultants throughout Arizona, highlighting upcoming events (i.e. conferences, video-conferencing, etc.), and available training opportunities. Also included is a link to bulletin boards from various agencies that contain issues, discussions, and other transportation-related information. This information will also be available on our web site www.azltap.org. If you are interested in joining our mailing list please contact Lori Sayers at lsayers@dot.state.az.us.

Employment Opportunity

AZ LTAP has a position opening for a Regional Trainer. The ideal applicant will preferably have 10 or more years in the transportation industry, preferably with at least 3 years of supervisory experience in a government setting. Candidates will posses knowledge and experience in Transportation Safety, Work Zone Traffic Control, Maintenance and Highway Construction, Highway Materials, basic surveying, communication, supervision, math (pertaining to transportation technologies) and other transportation related areas. Excellent verbal and written skills, experience in classroom instruction, techniques and curriculum development, Statewide travel is mandatory.

Interested applicants should send a detailed Resume by **April 15, 2003** to: Arizona Department of Transportation, Attn: Arizona LTAP Center, 1130 N. 22nd Ave., Mail Drop 069R, Phoenix, AZ 85009.

AZ LTAP Wants To Hear from You!

We are continuously looking for ways to improve our program to better serve your needs. If you have ideas, comments or suggestions regarding the program, please stop by the center, send us a letter or give us a telephone call at 1130 N. 22nd Ave., Mail Drop 069R, Phoenix AZ. 85009 (602)712-8461. We look forward to hearing from you!

Arizona LTAP Center
1130 N. 22nd Avenue
Phoenix Arizona 85009

Change Service Requested

Please share this newsletter with others.

- ☐ Supervisors
- ☐ Council Members
- ☐ Public Works Dept.
- ☐ Road/Maintenance Crew
- ☐ Managers
- ☐ City/County Engineers
- ☐ Mayors
- ☐ Others