

WESTSIDE EXTENSION TRANSIT CORRIDOR STUDY

Project No. PS-4350-2000

Task 13 Final Metro Red Line Vibration Study (10d and 10g) (REV 1-April 2011)

Prepared for:



Metro

Prepared by:

**Parsons Brinckerhoff
444 South Flower Street
Suite 3700**

Los Angeles, California 90071



April, 2011

Metro Red Line Vibration Study dated May 2009 (Preface – April 2011)

This Metro Red Line Vibration Study was conducted in 2009 to determine if the ground vibration at the surface of the existing Metro Red Line tunnels approach or exceed the FTA vibration impact criteria at tunnel depths similar to the Westside Extension Transit Corridor Project. The results indicated that the measured vibration levels during train operations could not be distinguished from the background ambient vibration levels generated by cars, buses, and trucks along the local surface streets. As a follow-up to this study more detailed analysis was conducted for the Draft and Final EIS/EIR of the Westside Subway Extension project using the measured vibration levels of the Red Line trains and by conducting transfer mobility tests of the soil to measure the attenuation of the soil conditions in the Westside study area. The more detailed studies consider the potential vibration effects of the Westside train operations on residential buildings. These findings will be available for public review as part of the Final EIS/EIR.

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1.0 INTRODUCTION

Metro successfully operates a large mass transit system comprised of traditional bus service, Bus Rapid Transit service (BRT), Light Rail Transit (LRT), and heavy rail transit (HRT) including surface and subway lines. Because Metro plans to substantially expand their heavy rail subway system into new areas that have no experience with a subway, this study was requested by Metro to objectively evaluate and document any train-related perceptible vibration at the ground surface above representative existing subway tunnels.

This report presents the results of a vibration study conducted above tunnels in which the Metro Red Line trains operate. The study was performed by Parsons Brinckerhoff (PB) acoustics and vibration specialists from September 2008 through March, 2009, with vibration measurements conducted between November 5, and November 21, 2008 and on February 25, 2009 and March 20, 2009.

1.1 Objectives

The objectives of this study were to:

- Select five locations on an existing subway line where train type and depth of the tunnel below ground would be similar to what is planned for the Westside Subway Extension
- Measure the existing ambient ground level vibration without a train passing underneath the measurement point but with other typical local activity present
- Attempt to measure vibration from a representative sample of passing underground trains to determine if there are measurable vibrations from the existing Metro Red Line operations, and
- Determine if subway-train-induced ground vibrations are perceptible to trained observers.

1.2 Background

Metro has never received any complaints about ground vibration caused by their heavy rail subway system operations. A few complaints were received during the construction of the subway tunnel system. With the advent of expansion of the subway into new areas, a concern about potential ground vibration from the new subway was voiced by persons who had experience only with shallow tunnel or depressed section tracks with a lid in other parts of the country, and not with the deep tunnel system implemented by Los Angeles County. Thus, this study was commissioned by Metro to document the Los Angeles County experience.



2.0 STUDY APPROACH

Working with Metro staff, PB's civil and vibration engineers reviewed the existing Metro Red Line subway system maps and drawings. This team of Metro and PB staff then visited potential measurement sites along the route to assess factors such as site access, community activity levels and building types. Based on the review and field observations, the team initially selected four measurement locations with a fifth measurement location added during the course of the study. These locations were subsequently revisited by PB specialists who cordoned off a small area of sidewalk with traffic delineators (skinny bright orange plastic tubes) and yellow "caution" tape. This kept casual pedestrians from walking too close to the extremely sensitive vibration sensor during the measurements. A 10 kg (22 pounds) solid steel seismic mass was placed at the surface over the tunnel (according to the tunnel drawings) and carefully leveled. The vibration sensor was affixed to the seismic mass with a threaded steel stud and its connecting cable was attached to the tripod-mounted vibration level monitor. Each measurement location was photographed and a Field Vibration Measurement Data Sheet (FVMDS) was prepared to record the location information, a sketch of the set-up, the instruments used, local activity, time of the measurement, etc.

In addition to the PB staff conducting the measurement, additional PB staff were positioned at the adjacent Metro Red Line subway station platforms to document train movements. Using a post-measurement review of the collected data, This allowed the measurement site staff to perform measurements both when trains were not passing under the measurement point and during periods when several trains necessarily passed under the measurement point. The guidance provided in the Federal Transit Administration (FTA) manual *Transit Noise and Vibration Impact Assessment*, May 2006 (Guidelines) indicates that four to six train pass-bys should be sufficient to characterize train vibration (assuming it can be measured). The minimum continuous measurement duration of one hour for each of the measurement periods was sufficient to accommodate approximately 12 train pass-bys.

The measurement site staff also purposefully tried to perceive train vibrations during periods of known train pass-bys at each measurement location. After the measurement period was concluded the digital measurement data stored in the vibration monitor was downloaded to a computer for subsequent analysis of the collected vibration data. Finally, the exact location of the vibration sensor was marked with a spot of orange surveyor's paint.

2.1 Instrumentation

The instrumentation used in this study consisted of a PCB Model 393B04 Piezoelectric accelerometer affixed with a steel stud to a machined steel seismic



mass. The accelerometer was attached by microdot type accelerometer cable to a Larson Davis model HVM-100 Vibration Monitor (VM). Larson Davis Blaze[®] software was used to transfer the data to a Dell personal computer for analysis. The VM was set to record the vibration velocity at a one second root-mean-square (rms) sample rate, linear (unweighted) frequency response, with a minimum bandwidth of 0.4 to 100 Hz. The use of the velocity parameter to describe the vibration is consistent with the FTA Guidelines. The Technical Data Sheets for the accelerometer and vibration monitor are included in Appendix A.

2.2 Measurement Locations

The measurements were conducted at:

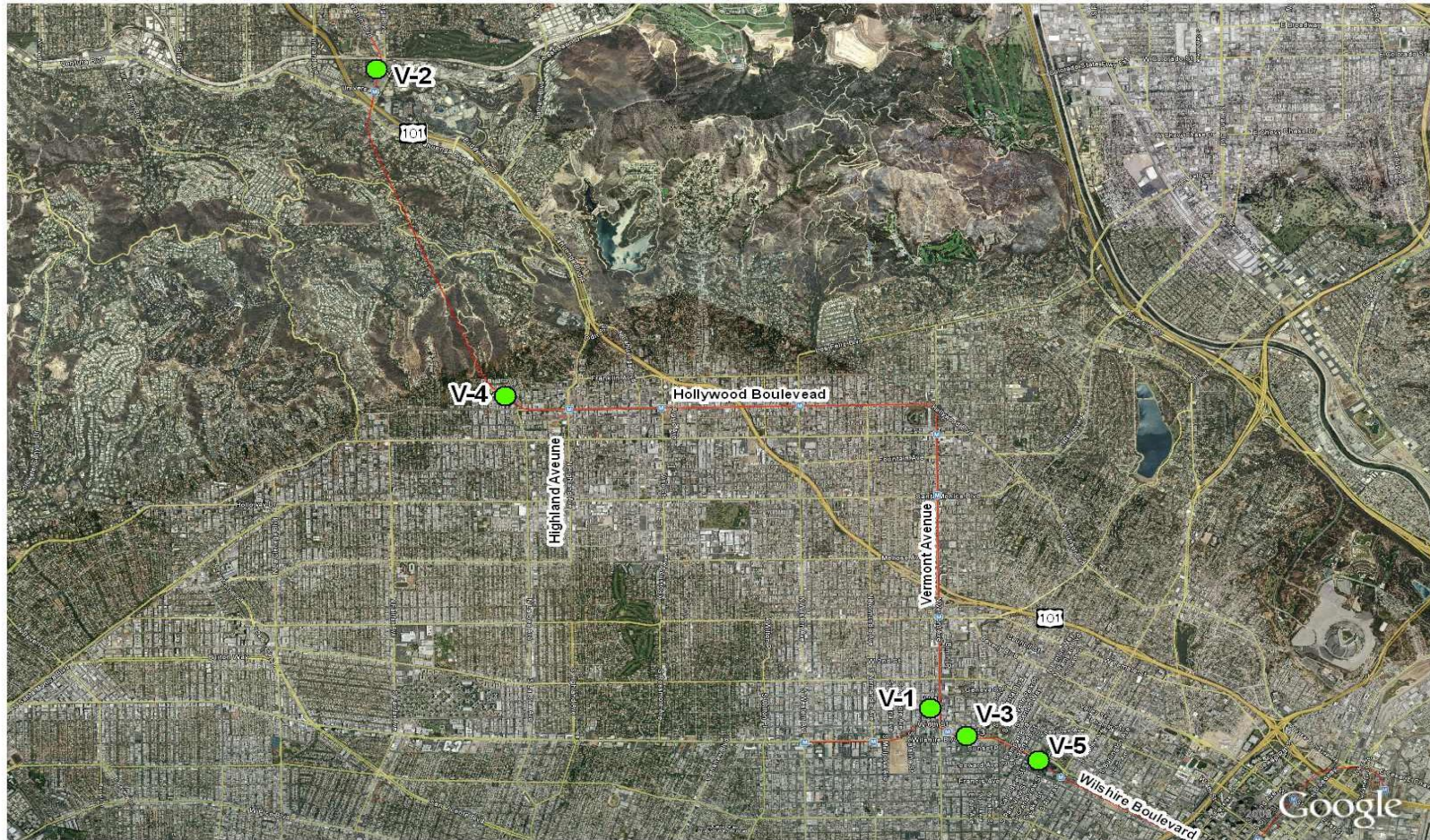
1. 3300 West 5th Street (Southeast corner of New Hampshire Avenue and West 5th Street), Los Angeles, CA 90020 (V-1)
2. North side of Valleyhart Drive (110 feet east of Willow Crest Avenue), Los Angeles, CA 91604 (V-2)
3. 3075 Wilshire Boulevard, Los Angeles, CA 90010 (V-3)
4. 7200 Franklin Avenue, Los Angeles, CA 90046 (V-4)
5. Southeast corner of South Park View Street and Wilshire Boulevard (slightly inside MacArthur Park, approximately 57 feet southeast of the street curb), Los Angeles, 90057 (V-5)

The locations relative to a portion of the Red Line route are shown on Figure 1. More detail views of these locations are provided on aerial photographs in Appendix B on Figures V-1 through V-5. The land use types, community activity, and depths-to-tunnel at these locations bracket the range of land use/building types, activity level, and tunnel depths that will be encountered in the extension project. The soil types and conditions along the Metro Red Line route are considered similar for general vibration transmission purposes to conditions likely to be encountered in the extension project. Photographs of each measurement location and set-up plus the FVMDS are included in Appendix B.

2.3 Data Reduction

The measured vibration data was converted to a vibration velocity level, in units of velocity decibels (VdB) relative to a reference velocity of 1 micro-inch per second. The use of velocity decibels to describe the vibration level with respect to human perception is consistent with the FTA Guidelines as presented in the following section from the FTA guidelines.

Figure 1. Measurement Locations





3.0 UNDERSTANDING GROUND-BORNE VIBRATION

Ground-borne vibration differs from airborne noise in that it consists of energy transmitted through the earth and not the air. It is not a widespread environmental problem, and is generally limited to localized areas very near roadways, rail systems, construction sites, and some industrial operations. Automobile, bus, and truck traffic rarely create perceptible ground-borne vibration, except where bumps, potholes, or other discontinuities in the roadway surface exist.

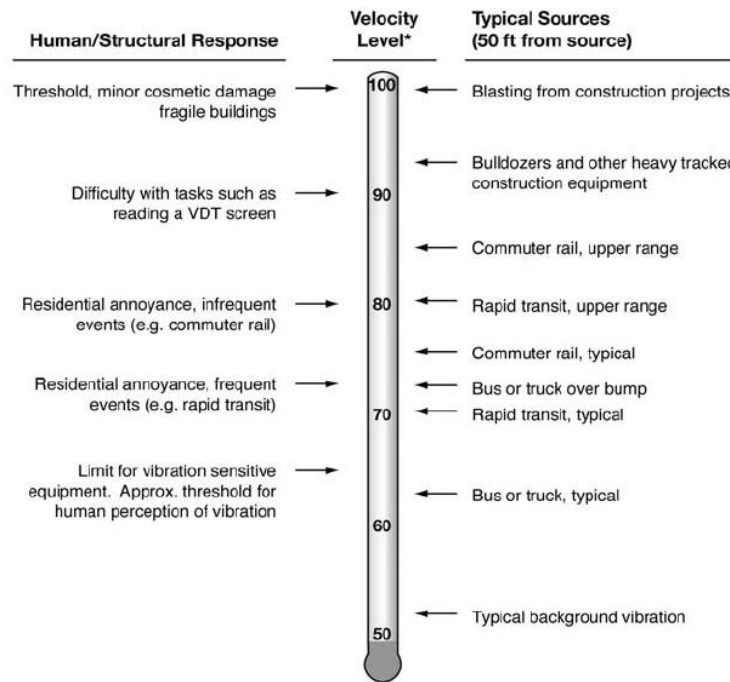
When traffic causes phenomena such as rattling windows, the cause is more likely to be acoustic (airborne) excitation rather than ground-borne vibration. The unusual situations where traffic or other existing sources cause intrusive vibration can be an indication of geologic conditions that could also result in higher-than-normal levels of train vibration.

Vibration is an oscillatory (back-and-forth) motion that can be described in terms of the displacement, velocity, or acceleration of the oscillations. Vibration velocity has been standardized as the metric for evaluating environmental vibration effects on humans. Therefore, vibration in this context usually is expressed in units of inches per second (ips). However, because of the very large velocity range over which typical environmental vibration energy can occur (below .001 to above 1.0 ips), a more convenient decibel scale has been adopted that allows for compression of this large range into a more practical scale. The velocity of vibration is expressed in units of decibels relative to one micro-inch per second, and the abbreviation VdB is used for vibration decibels to minimize confusion with sound decibels. The vibration level in most urban areas ranges typically from about 40 to 100 VdB.

Train vibration is almost always characterized in terms of the root-mean-square (RMS) amplitude. RMS is a widely used but sometimes confusing method of characterizing vibration and other oscillating phenomena. It represents the average energy over a short time interval; typically, a one-second interval is used to evaluate human response to vibration. RMS vibration velocity is considered the best available measure of potential human annoyance from ground-borne vibration because it has been shown to better correlate with the human body's response to vibration.

Existing background building vibration (with no obvious activity) usually ranges from 40 to 50 VdB, which is well below the range of human perception. Typical levels of ground vibration at a distance of 50 feet from the source are shown in Figure 2, on the FTA Guidelines Figure 7-3.

Figure 2. Typical Levels of Ground-Borne Vibration

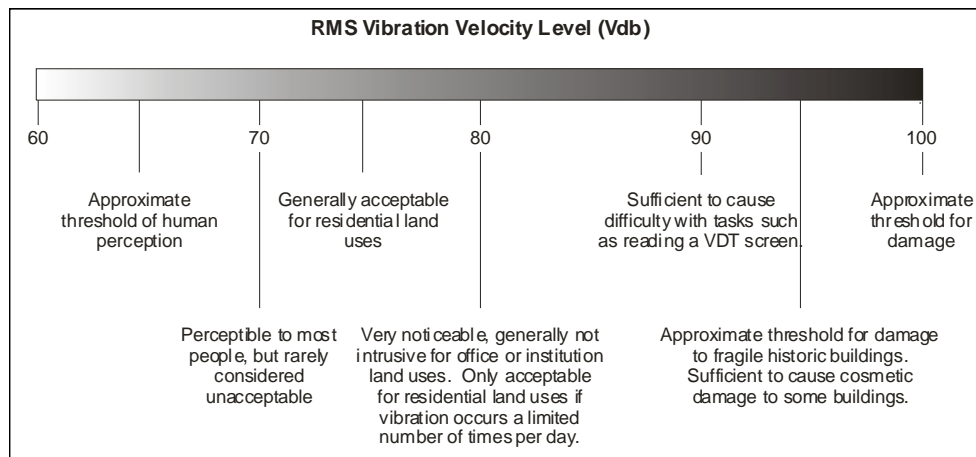


* RMS Vibration Velocity Level in VdB relative to 10^{-6} inches/second

Source: Figure 7-3, FTA Guidelines

Although the perceptibility threshold is about 65 to 70 VdB, human response to vibration is usually not significant unless the RMS vibration velocity level exceeds 70 VdB as shown in Figure 3, below.

Figure 3. Levels and Effects of Ground-Borne Vibration



Source: Transit Noise and Vibration Impact Assessment, FTA, May 2006



The FTA vibration impact criteria are presented in the Results and Comparison to Standards Chapter (6.0).

4.0 MEASUREMENT RESULTS

Table 1, below, contains the brief (1 second) maximum vibration velocity levels measured during ambient no-train conditions and during train pass-by conditions at each of the four sites.

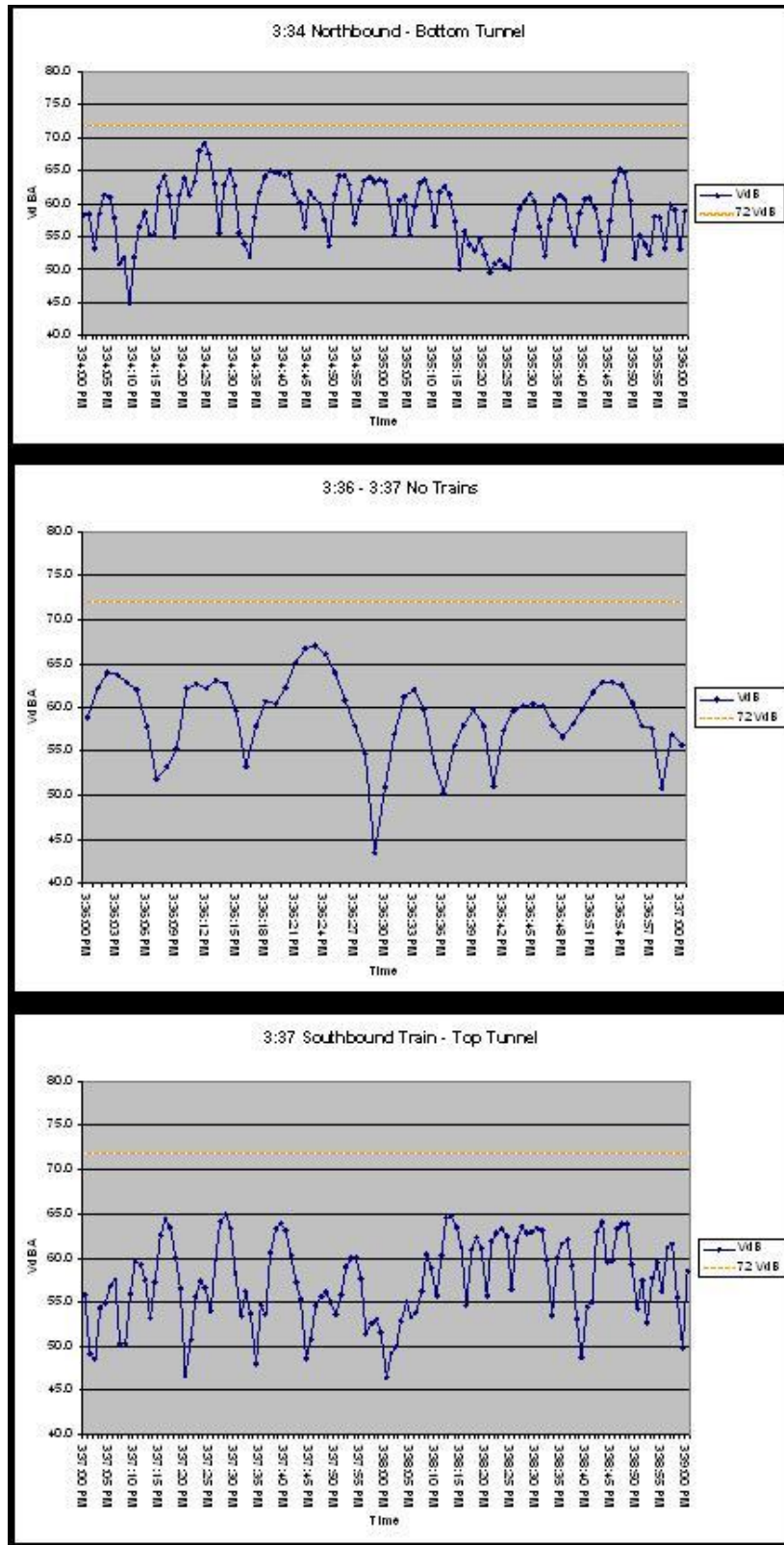
Table 1. Maximum Measured Vibration Levels

Site	Depth to Rail	FTA Impact Threshold for Residential Use	Maximum VdB No-Trains/Time	Maximum VdB during N/B train activity/Time	Maximum VdB during S/B train activity/Time
V-1 (West 5 th)	56 feet to SB 98 feet to NB	72 VdB	70 VdB/3:26:04	70 VdB/3:26:00	69 VdB/3:27:01
V-2 (Valleyhart)	55 feet	72 VdB	78 VdB/3:41:54	76 VdB/3:26:04	76 VdB/3:26:04
V-2S (Valleyhart)	55 feet	72 VdB	69 VdB/2:00:34	69 VdB/2:01:34	68 VdB/1:51:02
V-3 (Wilshire)	58 Feet SB 99 Feet NB	72 VdB	72 VdB/3:00:11	73 VdB/3:22:31	76 VdB/2:59:44
V-4 (Franklin)	64 feet	72 VdB	75 VdB/2:27:13	73 VdB/2:45:47	73 VdB/2:31:31
V-5 (MacArthur)	65 feet	72 VdB	65 VdB/3:11:02	64 VdB/3:45:49	64 VdB/4:03:48

It is interesting to note that for most locations the maximum vibration levels occurred during periods with no subway train activity. The relatively high vibration levels noted at Location V-2 (Valleyhart) did not seem reasonable based on the existing activity during the measurement period. Thus, this location was re-measured and the supplemental data is shown for V-2S. The elevated vibration level at the Wilshire Boulevard location V-3 during S/B train activity is likely from the proximity of the vibration sensor to street-level bus and heavy-truck traffic. These issues will be discussed further in the Data Analysis section.

The representative vibration time-history data plots (1-second rms velocity level in VdB versus time) for each of the measurement locations are shown on Figures V-1A through V-5E contained in Appendix C.

Figure 4 (Figure V-1B from Appendix C: Southeast corner of New Hampshire Avenue and West 5th Street) is also presented below to illustrate the variation in vibration level with time during two typical periods with train activity (top and bottom graphs) compared to a no-trains period (middle graph) and to the FTA impact criterion of 72 VdB. The graph indicates vibration levels in increments of five VdB. Note that the measured vibration levels are very similar and all are below 72 VdB for this location.

Figure 4. Observed Vibration Levels (New Hampshire Avenue and West 5th)




5.0 DATA ANALYSIS

The first level of analysis was to look at the ambient-no-train VdB level to benchmark, or establish a baseline range, for each location. Attempts were then made to observe any train-pass-by-related periodicity in the plots of vibration level versus time. By visual inspection of Figures V-1A through V-5E (Appendix C), any coherence between slight increases in vibration at roughly the train headway intervals is virtually non-existent. More important, however, is that maximum vibration levels during periods of train pass-bys are very similar to the levels during ambient no-train-activity periods.

Analyses of the data collected at the Valleyhart and at the Wilshire locations merit additional discussion. There were some infrequent higher levels of vibration noted from the data collected at the Wilshire location V-3. Based on contemporaneous field observations, these short-term spikes in vibration level are likely caused by the passing of heavy vehicles such as trucks and busses along the street which was relatively close to the vibration sensor due to space constraints at this location. The cause of higher levels of vibration measured during approximately one-half of the measurement period at the Valleyhart location (V-2 in Table 1 above) is not readily apparent. Based on contemporaneous field observations by PB staff at this location there were no obvious sources of vibration other than the typical passage of light-duty vehicles and the hand unloading of furniture from a moving van. The time distribution of the higher (atypical) and lower (typical) ambient vibration levels was also unusual. Finally, the experienced field staff noted no perceptible vibration even though the data suggested that vibration should have been slightly perceptible. Our conjecture is that electrical interference, or some unknown vibration source may have been the cause of the anomalous readings. In order to gain more insight and confidence in our evaluation of existing vibration levels at the Valleyhart location, the exact location was subsequently re-measured for the same duration during a similar period. This supplemental vibration data is summarized in the row for V-2S in Table 1. This data reveals vibration levels that are more typical for a fairly quiet residential street with low vehicular traffic volume. The vibration levels did not exhibit any special time-related characteristics during the measurement period, and again no perceptible vibration was experienced by the field staff.



6.0 RESULTS AND COMPARISONS TO STANDARDS

The ambient baseline vibration levels measured at the five locations are similar to those resulting from typical community activities at similar locations. The results may be observed by comparison of the time history plots of no-train activity at the five locations relative to each other and to the data contained in FTA Figure 7-3 presented above as Figure 2.

Importantly, the results of measurements conducted during subway train activity, as summarized in Table 1 and presented on Figures V-1A through V-5E (Appendix C), are below the FTA vibration impact criterion in residential areas. The results of the measurements performed during periods of subway train activity were similar to those during no-train periods. A brief discussion of the FTA impact criteria follows.

6.1 FTA Vibration Impact Criteria

The FTA has developed impact criteria for acceptable levels of ground-borne vibration and ground-borne noise guidelines. Ground-borne vibration from transit vehicles is characterized in terms of the root-mean-square (RMS) vibration velocity amplitude. The threshold of vibration perception for most humans is around 65 to 70 vibration decibels (VdB). Levels in the 70 to 75-VdB range are often noticeable but acceptable, and levels greater than 80 VdB are often considered unacceptable. For urban transit systems with 10 to 20 transit movements per hour throughout the day, limits for acceptable levels of residential ground-borne vibration are usually between 70 and 75 VdB.

FTA's and other professional's experience with ground-borne vibration from rail systems and other common vibration sources suggests the following:

- Ground-borne vibration from transit vehicles should be characterized in terms of the RMS vibration velocity amplitude. A one-second RMS time constant is assumed. This is in contrast to vibration from blasting and other construction procedures that could cause building damage that is usually described in terms of the peak particle velocity.
- The threshold of vibration perception for most humans is around 65-70 VdB; levels in the 70 to 75-VdB range are somewhat to often noticeable but acceptable; and levels greater than 80 VdB are often considered unacceptable.
- For human annoyance, there is some relationship between the number of events and the degree of annoyance caused by the vibration (assuming that the vibration "event" is perceptible). It is intuitive to expect that more frequent vibration events, or events that last longer, will be more annoying to building occupants. To account for the fact that most commuter rail systems have



fewer daily operations than the typical urban transit line, the criteria in the FTA Guidelines include an 8-VdB-higher impact threshold if there are fewer than 70 train pass-bys per day, regardless of the number of cars per train. Thus, for commuter rail systems with less than 70 trains per day, the limit for an acceptable level of residential ground-borne vibration is 80 VdB.

- Ground-borne vibration from any type of train operation will rarely be high enough to cause any sort of building damage, even minor cosmetic damage. The only real concern is that the vibration will be intrusive to building occupants or interfere with vibration-sensitive equipment.
- The vibration of floors and walls may cause a rumble noise within a building. This rumble is the noise radiated from the motion of the room surfaces. In essence, the room surfaces act like a giant loudspeaker. This is called *ground-borne noise*. This effect may present a concern for especially noise-sensitive buildings such as concert halls and recording studios.

The FTA impact criteria for ground-borne vibration is summarized in Table 2. These criteria are based on previous standards, criteria, and design goals, including the American National Standards Institute (ANSI) S3.29 (Acoustical Society of America, 1983) and the noise and vibration guidelines of the American Public Transit Association (APTA 1981). These criteria do not include buildings such as concert halls, television and recording studios, and theaters that can be very sensitive to vibration but do not fit into any of the three categories.

Table 2. FTA Ground-Borne Vibration Impact Criteria

Land Use Category	Ground-Borne Vibration Impact Levels (VdB re: 1 micro-inch/sec)	
	Frequent Events ¹	Infrequent Events ²
Category 1: Buildings where low ambient vibration is essential for interior operations	65VdB ³	65VdB ³
Category 2: Residences and buildings where people normally sleep	72 VdB	80 VdB
Category 3: Institutional land uses with primarily daytime use	75 VdB	83 VdB

Source: *Transit Noise and Vibration Impact Assessment*, FTA, May 2006

Notes:

¹ "Frequent Events" is defined as more than 70 vibration events per day

² "Infrequent Events" is defined as fewer than 70 vibration events per day. This category includes most commuter rail systems.

³ This criterion is based on levels that are acceptable for most moderately sensitive equipment, such as optical microscopes. Vibration-sensitive manufacturing or research uses will require detailed evaluation to define acceptable vibration levels. Ensuring lower vibration levels in a building often requires special design of the HVAC system and stiffened floors.



6.2 Findings

PB professional specialists measured ground vibration during periods of no subway train activity and periods with subway train activity. We found that vibration levels during no subway train activity (“ambient”) is slightly higher than what FTA (Figure 2) shows as “typical background” vibration levels for some of the measurement locations. This is expected, given that Los Angeles is a busy urban environment with substantial movement of heavy motor vehicles, and distant construction and/or mechanical equipment activity.

We also found that vibration levels at the ground surface during a substantial sample period of train movements through Metro Red Line subway tunnels of varying depth are essentially indistinguishable from the ongoing ambient vibration caused by typical community activity and background earth micro-motion. No identifiable train vibration pattern emerges from inspection of the collected data. The subway train vibrations are not measurable as separate and distinct vibration events. They blend into the ambient vibration from normal community activity and earth movement. The measured vibration levels are predominately below, and do not violate, any applicable vibration standards.

The vibration measurement system was sensitive enough to capture the small vibration levels from heavy truck and bus movements on adjacent roadways. However, PB’s experienced vibration specialists did not perceive ground vibration at any time during the measurements at any of the locations. This includes the nearby movement of heavy trucks and busses on adjacent streets, the passage of underground trains, and one occasion when a compact car entered a driveway apron about 20 feet away with enough speed and force to temporarily overload the vibration measurement system.



7.0 CONCLUSIONS AND RECOMMENDATIONS

The vibration from Metro heavy rail subway trains is not perceptible even directly above tunnels at depths ranging from 55 feet to 99 feet below ground. The operation of the existing subway is in compliance with all ground vibration criteria and standards regarding human perception of vibration. Measured ground vibration levels during operation of the Metro Red Line subway did not exceed the FTA ground level criterion of 72 VdB for residential buildings and other structures where people normally sleep (Category 2) at any residential location. Operation of the Metro Red Line subway does not cause vibration annoyance conditions.

The vibration levels likely to be generated by the future extension of the subway are expected to be very similar to vibration from the existing Metro Red Line, assuming similar operational and design parameters of railcars, speeds, track type, crossover/turnout frog type, curve radii, and tunnel depth. Thus, we believe that the tradition of vibration-complaint-free operation of the Metro subway system will continue. We recommend that vibration-related operational and design factors be considered in the design and operation of future subway extensions or new separate lines.



8.0 REFERENCES

California Department of Transportation, Division of Environmental Analysis. February 2002. TAV-02-01-R9601. *TRANSPORTATION RELATED EARTHBORNE VIBRATIONS*. Office of Noise, Air Quality, and Hazardous Waste Management. Sacramento, CA.

LA MTA - Contract No. B201 Drawings C-008 to C-0013

LA MTA - Contract No. B 211 Drawings M-001, RW B-006, C-007

LA MTA - Contract No. B 251 Drawings C-101 to C-103

LA MTA - Contract No. C 331 Drawings C-002, C-004

LA MTA - Contract No. C0311 Drawings C-051 to C-055

U.S. Department of Transportation, Federal Transit Administration (FTA). May 2006. FTA-VA-90-1003-06. *Transit Noise and Vibration Impact Assessment*. Office of Planning and Environment. Washington, DC.



APPENDIX A





Industrial Hygiene Vibration Monitor

Complete Convenient System for Exposure Limit Compliance Testing

Highlights

- Frequency weightings and measurements for hand-arm and whole-body vibration
- Conforms to ISO 2631 and 5349; Type 1 instrument per ISO 8041
- Simultaneous 3-channel measurements: X, Y and Z axes, plus Sum (S)
- Lightweight and portable
- Records up to 200 hours of time history
- Programmable AC or DC signal output
- Interface-to PC (USB/Serial).

Applications

- Worker exposure assessment
- Compliance with EU Physical Agents Directive 2002/44/EC
- Ergonomic evaluation
- Workstation design and optimization
- Quantify risk of injury per accepted permissible exposure limits
- Qualify hand-tool performance
- Determine effectiveness of anti-vibration gloves and materials



HVM100 is ideal for hand-arm and whole-body exposure assessments

Exposure to high levels of vibration has been shown to cause permanent injury if left unchecked and untreated. Determining potential for injury from exposure to vibration should be considered part of a comprehensive ergonomic evaluation and risk assessment program.

Model HVM100 from Larson Davis provides a portable, practical means for quantifying exposure data on the job, whether the work is performed inside manufacturing or process plants or at the most remote agricultural, mining or construction sites.

Wherever there is work to be done using heavy mobile equipment or rotating reciprocating hand tools powered by air, electricity, or internal combustion, the HVM100 is the easy way to obtain and document the levels of exposure that have been proven to cause a wide range of potential injury including Hand-arm Vibration Syndrome (HAVS – also known as 'Vibration White Finger Disease' or VWF) and other more insidious physical effects.



HVM100

Certificate of Calibration and Conformance

Certificate Number 2008-109032

Instrument Model HVM100, Serial Number 00227, was calibrated on 30JUL2008. The instrument meets factory specifications per Procedure D0001.8098, ISO 8041:1990(E).

Instrument found to be in calibration as received: YES

Date Calibrated: 30JUL2008

Calibration due: 30JUL2009

Calibration Standards Used

MANUFACTURER	MODEL	SERIAL NUMBER	INTERVAL	CAL. DUE	TRACEABILITY NO.
Larson Davis	LD5igGn/2209	0653 / 0101	12 Months	21FEB2009	2008-103763

Reference Standards are traceable to the National Institute of Standards and Technology (NIST)

Calibration Environmental Conditions

Temperature: 24 ° Centigrade

Relative Humidity: 30 %

Affirmations

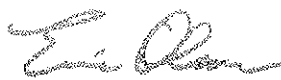
This Certificate attests that this instrument has been calibrated under the stated conditions with Measurement and Test Equipment (M&TE) Standards traceable to the U.S. National Institute of Standards and Technology (NIST). All of the Measurement Standards have been calibrated to their manufacturers' specified accuracy / uncertainty. Evidence of traceability and accuracy is on file at Provo Engineering & Manufacturing Center. An acceptable accuracy ratio between the Standard(s) and the item calibrated has been maintained. This instrument meets or exceeds the manufacturer's published specification unless noted.

This calibration complies with the requirements of ISO 17025 and ANSI Z540. The collective uncertainty of the Measurement Standard used does not exceed 25% of the applicable tolerance for each characteristic calibrated unless otherwise noted.

The results documented in this certificate relate only to the item(s) calibrated or tested. A one year calibration is recommended, however calibration interval assignment and adjustment are the responsibility of the end user. This certificate may not be reproduced, except in full, without the written approval of the issuer.

"AS RECEIVED" data same as shipped data

Signed:



Technician: Eric Olson

~ Calibration Certificate ~

Per ISO 16063-21

Model Number: 393B04

Serial Number: 23354

Description: ICP® Accelerometer

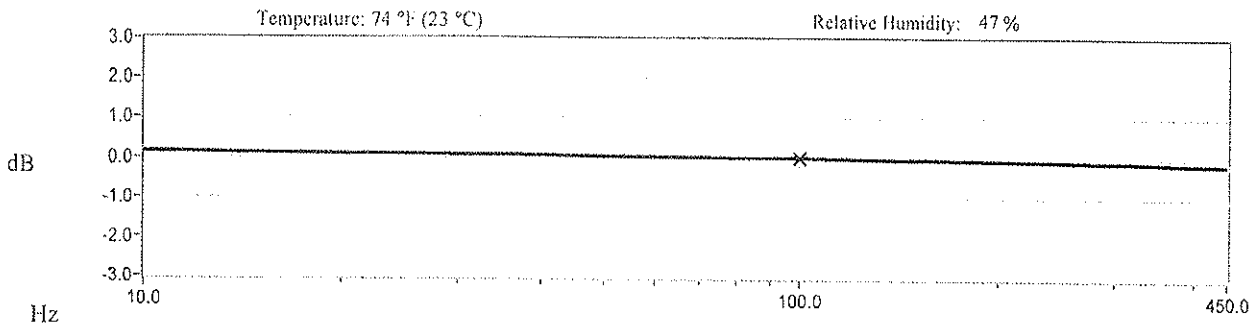
Method: Back-to-Back Comparison Calibration

Manufacturer: PCB

Calibration Data

Sensitivity @ 100.0 Hz	1019 mV/g	Output Bias	11.4 VDC
	(103.9 mV/m/s ²)	Transverse Sensitivity	3.3 %
Discharge Time Constant	11.1 seconds	Resonant Frequency	3001.7 Hz

Sensitivity Plot



Data Points

Frequency (Hz)	Dev. (%)	Frequency (Hz)	Dev. (%)
10.0	1.6	300.0	-1.2
15.0	1.4	450.0	-1.8
30.0	0.8		
50.0	0.4		
REF. FREQ.	0.0		

Mounting Surface: Stainless Steel w/Silicone Grease Coating Fastener: Stud Mount

Fixture Orientation: Vertical

Acceleration Level (ms²): 1.00 g (9.81 m/s²)

*The acceleration level may be limited by shaker displacement at low frequencies. If the listed level cannot be obtained, the calibration system uses the following formula to set the vibration amplitude. Acceleration Level (g) = 0.010 x (freq).

Condition of Unit

As Found: n/a

As Left: New Unit, In Tolerance

Notes

1. Calibration is NIST Traceable thru Project 822/274086 and PTB Traceable thru Project 1060.
2. This certificate shall not be reproduced, except in full, without written approval from PCB Piezotronics, Inc.
3. Calibration is performed in compliance with ISO 9001, ISO 10012-1, ANSI/NCSL Z540-1-1994 and ISO 17025.
4. See Manufacturer's Specification Sheet for a detailed listing of performance specifications.
5. Measurement uncertainty (95% confidence level with coverage factor of 2) for frequency ranges tested during calibration are as follows: 5-9 Hz; +/- 2.0%, 10-99 Hz; +/- 1.5%, 100-1999 Hz; +/- 1.0%, 2-10 kHz; +/- 2.5%.

Technician: Dave Grotke

Date: 12/26/07



3425 Walden Avenue · Depew, NY 14043

TEL: 888-684-0013 · FAX: 716-685-3886 · www.pcb.com



~ Calibration Certificate - Phase ~

Per ISO 16063-21

Model Number: 393B04

Serial Number: 23354

Description: ICP® Accelerometer

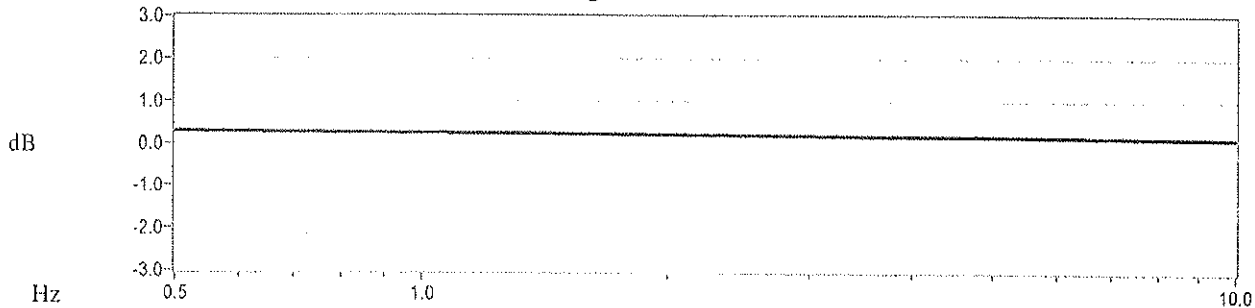
Method: Back-to-Back Comparison Calibration

Manufacturer: PCB

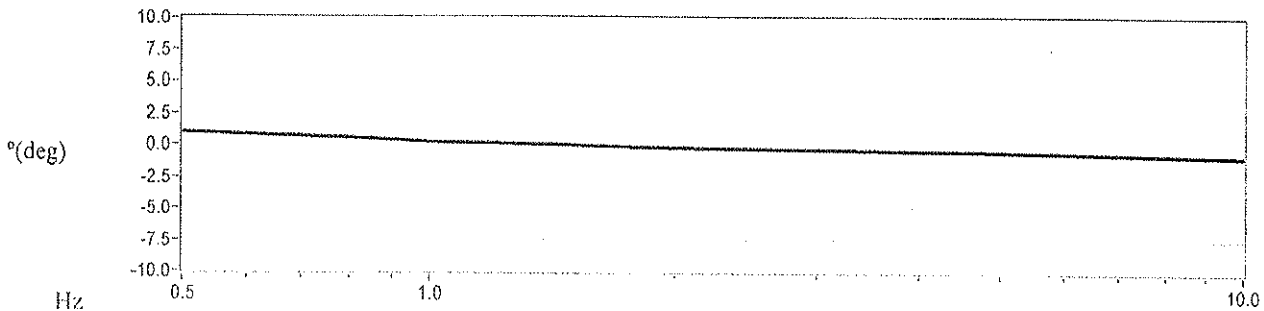
Calibration Data

Sensitivity @ 100.0 Hz 1019 mV/g (103.9 mV/m/s²)

Magnitude Plot



Phase Plot



Data Points

Frequency (Hz)	Deviation (%)	Phase (°)
0.5	3.4	1.0
1.0	3.1	0.2
2.0	2.6	-0.2
5.0	2.0	-0.6
7.0	1.8	-0.7
10.0	1.6	-0.9

Notes

1. Calibration is traceable to one or more of the following report numbers; PTB 5399, PTB 5400 and NIST 822/271196.
2. This certificate shall not be reproduced, except in full, without written approval from PCB Piezotronics, Inc.
3. Calibration is performed in compliance with ISO 9001, ISO 10012-1, ANSI/NC SL Z540-1-1994 and ISO 17025.
4. See Manufacturer's Specification Sheet for a detailed listing of performance specifications.
5. Measurement uncertainty (95% confidence level with coverage factor of 2) for frequency ranges tested during calibration are as follows: 0.5-0.99 Hz; +/- 1.8%, 1-30 Hz; +/- 1.0%, 30.01-199 Hz; +/- 1.5%. 200-1 kHz; +/- 3.0%.

Technician: Dave Grotke

Date: 12/26/07



3425 Walden Avenue · Depew, NY 14043

TEL: 888-684-0013 · FAX: 716-685-3886 · www.pcb.com



Model Number
352C68

ACCELEROMETER, ICP®

Revision L

	ENGLISH	SI
Performance		
Sensitivity (±10 %)	100 mV/g ±50 g pk	10.2 mV/(m/s ²) ±491 m/s ² pk
Measurement Range	0.5 to 10000 Hz	0.5 to 10000 Hz
Frequency Range (±5 %)	0.3 to 12000 Hz	0.3 to 12000 Hz
Frequency Range (±10 %)	0.2 to 20000 Hz	0.2 to 20000 Hz
Frequency Range (±3 dB)	2.35 kHz	2.35 kHz
Resonant Frequency	2 to 5000 Hz	2 to 5000 Hz
Phase Response (±5 °) (at 70°F [21°C])	0.00016 g rms	0.0015 m/s ² rms
Broadband Resolution (1 to 10000 Hz)	≤1 %	≤1 %
Non-Linearity	≤5 %	≤5 %
Transverse Sensitivity		
Environmental		
Overload Limit (Shock)	±5000 g pk	±49050 m/s ² pk
Temperature Range (Operating)	-65 to +200 °F	-53 to +93 °C
Temperature Response	See Graph	See Graph
Base Strain Sensitivity	≤0.005 g/µe	≤0.05 (m/s ²)/µe
Electrical		
Excitation Voltage	18 to 30 VDC	18 to 30 VDC
Constant Current Excitation	2 to 20 mA	2 to 20 mA
Output Impedance	≤300 ohm	≤300 ohm
Output Bias Voltage	8 to 12 VDC	8 to 12 VDC
Discharge Time Constant	0.8 to 2.4 sec	0.8 to 2.4 sec
Settling Time (within 10% of bias)	<10 sec	<10 sec
Spectral Noise (1 Hz)	60 µg/√Hz	588 (µm/s ²)/√Hz
Spectral Noise (10 Hz)	16 µg/√Hz	157 (µm/s ²)/√Hz
Spectral Noise (100 Hz)	5 µg/√Hz	49 (µm/s ²)/√Hz
Spectral Noise (1 kHz)	1.5 µg/√Hz	14.7 (µm/s ²)/√Hz
Physical		
Sensing Element	Ceramic	Ceramic
Sensing Geometry	Shear	Shear
Housing Material	Titanium	Titanium
Sealing	Welded Hermetic	Welded Hermetic
Size (Hex x Height)	0.28 in x 0.73 in	7.1 mm x 18.5 mm
Weight	0.070 oz	2.0 gm
Electrical Connector	10-32 Coaxial Jack	10-32 Coaxial Jack
Electrical Connection Position	Top	Top
Mounting Thread	5-40 Male	5-40 Male
Mounting Torque	8 to 12 In-lb	90 to 135 N-cm

[1]

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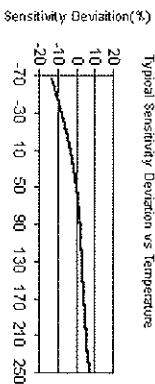
[1]

[1]

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All specifications are at room temperature unless otherwise specified. In the interest of constant product improvement, we reserve the right to change specifications without notice. ICP® is a registered trademark of PCB group, Inc.

Optional Versions (Optional versions have identical specifications and accessories as listed for standard model except where noted below. More than one option may be used.)

A - Adhesive Mount

Supplied Accessory: Model 080A90 Quick bond Gel (for use with accelerometer adhesive ring bases to fill gaps on rough surfaces); replaces Model 080A15

HT - High temperature, extends normal operation temperatures

Frequency Range (5 %)

Frequency Range (10 %)

Frequency Range (3 dB)

Temperature Range (Operating)

Discharge Time Constant

Broadband Resolution (1 to 10000 Hz)

Spectral Noise (1 Hz)

Spectral Noise (10 Hz)

Spectral Noise (100 Hz)

Spectral Noise (1000 Hz)

J - Ground Isolated

Frequency Range (5 %)

Frequency Range (10 %)

Frequency Range (3 dB)

Resonant Frequency

Electrical Isolation (Base)

Size (Hex x Height)

Weight

M - Metric Mount

Mounting Thread

Supplied Accessory: Model M080A15 Metric adhesive base, 0.31" hex x 0.125" thk, M3 x 0.50 thd, aluminum with insulating hardcoat finish replaces Model 080A15

W - Water Resistant Cable

Electrical Connector

Electrical Connection Position

Sealed Integral Cable Side

Sealed Integral Cable Side

Notes

[1] Typical.

[2] 200°F to 250°F data valid with HT option only.

[3] Zero-based, least-squares, straight line method.

[4] Transverse sensitivity is typically ≤ 3%.

[5] See PCB Declaration of Conformance PS023 for details.

[6] Mounting stud removed, adhesive mounting base not required.

Supplied Accessories

080A109 Petro Wax (1)

080A15 Adhesive Mounting Base (1)

ACS-1 NIST traceable frequency response (10 Hz to upper 5% point). ()

Entered: LLH	Engineer: GZ	Sales: WDC	Approved: JJB	Spec Number:
Date: 11/02/2005	Date: 11/02/2005	Date: 11/02/2005	Date: 11/03/2005	8337



Address: 3425 Walden Avenue
Depew, NY 14043
United States



Industrial Hygiene Vibration Monitor

HVM100 Simplifies Vibration Exposure Monitoring

HVM100 is a hand-held instrument for measuring human exposure to vibration, performing relevant calculations and providing overall metrics on its LCD display. Detailed vibration levels are easily stored in its built-in data logger, which can hold up to 100 separate time-history test files including all required metrics. This information can then be downloaded to a PC for analysis and archiving.

Measuring all three axes of vibration simultaneously greatly simplifies the setup of a test and enhances the repeatability and correlation of the vibration data. From the three channels of measured data, the HVM100 automatically calculates vector sum information and presents it as a fourth set of data values. For compliance with the latest measurement standards, the HVM100 employs digital filters for each channel that can be enabled as needed, and will never be obsolete – should standards change, the filters can be upgraded electronically!



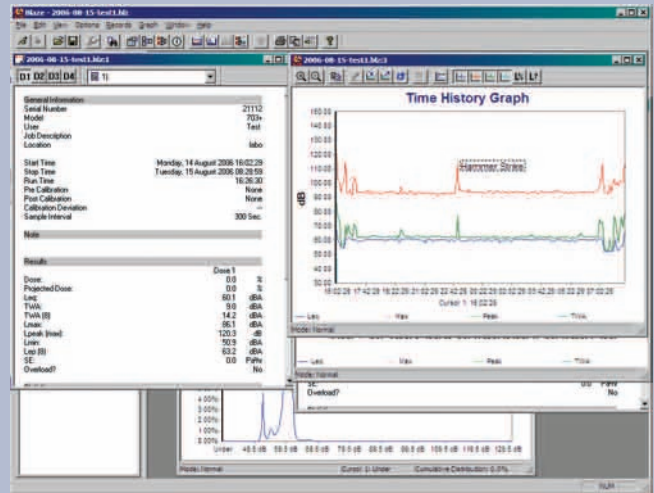
Configured as a complete system, including everything from sensors to software, HVM100 comes with everything you need to confidently generate meaningful exposure documentation. From mechanical hand-arm adapters that locate the sensors properly in relation to the operator's grip of the tool – or a 'seat-pad' accelerometer for measuring whole-body vibration, you'll have all the right bits and pieces to make measurements accurately and consistently. What's more, with Blaze® software, you'll have a simple means of setting up a test, controlling the instrument and analyzing the resulting data.

To increase user-friendliness, the HVM100 comes standard with four out of eight possible language options – including Italiano, Español, and Deutsch (Italian, Spanish, German)! Any way you say it, the HVM100 is the best solution for Safety and Health professionals when it comes to vibration exposure monitoring.

Glove Transmissibility Measurement:

Only Larson Davis offers a unique 'Palm Adapter' that locates a sub-miniature triaxial accelerometer (sensor) in a specially designed 'cup'. This cup fits unobtrusively in the worker's palm, and can measure the vibration levels with and without a vibration damping glove in place – thus providing you real data on attenuation levels!

Supported by BLAZE® Application Software



Blaze® is the Industrial Hygiene and Safety Professional's analysis package of choice – combining ease-of-use with powerful reporting capability, Blaze® makes gathering and managing your vibration exposure data an absolute breeze! Combining summary data and a concise color graph of the vibration levels over time on just one page, you can easily present reports that are clear and understandable by workers and management alike. The ability to present detailed time-history reports and labeled graphs in addition to the summary reports gives even more presentation options.



Also available
HVManager™
See separate
data sheet.

Blaze® makes instrument calibration, setup and deployment a snap – no need to press any keys – if you prefer, simply create and store multiple setup files in a Blaze® 'library' to cover all your possible measurement applications. Blaze® even stores individual calibration data on all your accelerometers, and makes changing from hand-arm to whole-body measurement setups in the field effortless and foolproof!

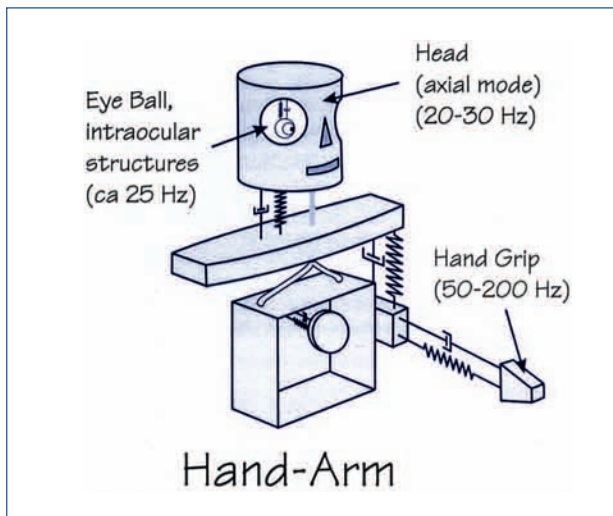
And for those who do noise exposure monitoring, you'll be glad to know Blaze® supports the Larson Davis Spark® series personal noise dosimeters and the SoundTrack LxT® octave band sound level meters, too! Contact your Larson Davis representative for information.

About Human Exposure to Vibration in the Workplace

Risks to workers from exposure to high levels of vibration include decreased performance and even permanent injury. Two common types of vibration exposure have been identified as deleterious: hand-arm vibration and whole-body vibration.

These exposures are prevalent in the following industries:

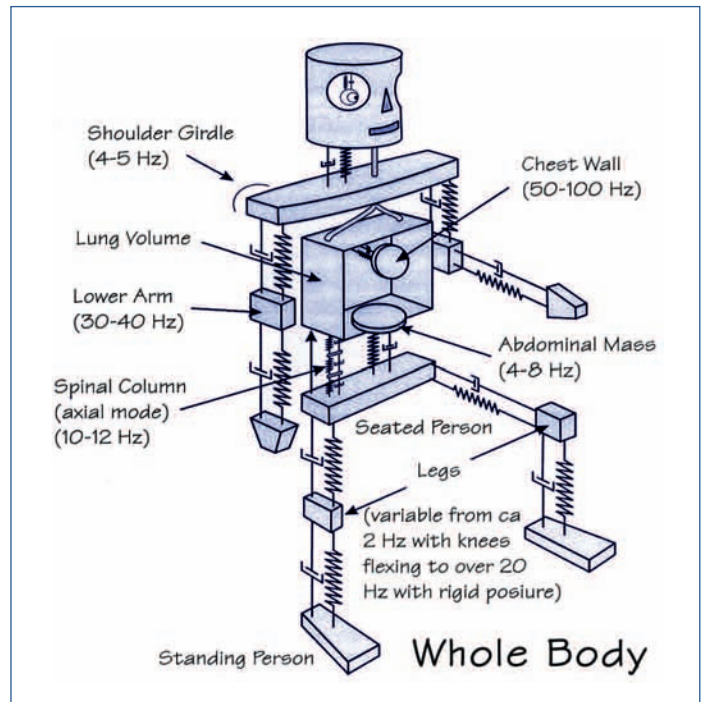
- Foundries / Metalworking
- Shipbuilding
- Transportation / Material Handling
- Construction
- Logging
- Mining



Worker exposure to high levels of vibration from powered hand tools can cause vibration syndrome symptoms such as numbness, pain, tingling and blanching. Vibration syndrome exposures induce adverse circulatory and neural effects in the fingers and hands that can become irreversible if left unchecked over as little as one year's time. Reduced tactile feeling and dexterity resulting from these exposures decreases workers' ability to perform critical tasks with precision. Often called vibration white finger disease (VWF), this condition is progressive and debilitating. Pneumatic- and electric-powered hand tools are often the cause of these unacceptable exposure levels, and even hand tools that were initially selected to emit lower levels of vibration may degrade through typical use and improper maintenance, leading to increasing and ultimately unacceptable levels of exposure over the working life of the tool.

High levels of whole-body vibration exposure are common to workers who operate heavy machinery, material handling and transport equipment, or whose operator stations are in proximity to heavy rotating, stamping or reciprocating machinery. Physical effects to the worker can include damage to the spinal column, and can manifest as low back pain or back, neck and shoulder disorders. Some studies point to possible negative reproductive effects in female populations exposed to high levels of whole-body vibration.

Until now, it has been difficult to quantify these exposures accurately and consistently. Vibration must be measured in three directions, or axes, simultaneously and this acceleration information must be integrated into useful values and scientific units of measure. Further, measuring the frequency range of the vibration is critical to assessing the potential for physical damage. For example, the frequencies of interest in determining potential injury from hand tools are as high as 1000 Hz, whereas whole-body vibration exposures are most damaging at lower frequencies – in the case of the spinal column, primarily from about 0.5 to 80 Hz.

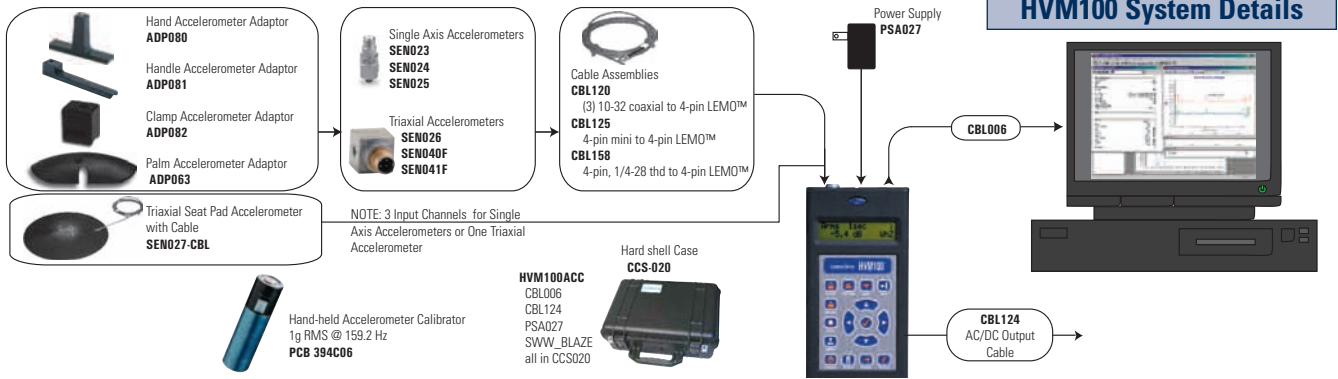


Recent ISO and ANSI standards have been promulgated that define measurement criteria and exposure limits that are useful and practicable for Safety and Industrial Hygiene professionals to implement. This methodology uses a broadband measurement of only the frequencies of interest for determining the severity of the two main types of exposures. This approach simplifies the number of readings that must be taken, and as implemented in HVM100, vastly increases the speed at which an accurate assessment can be made.





Industrial Hygiene Vibration Monitor



HVM 100

Technical Specifications

Input types	ICP® sensors, direct voltage
Input range	>100 dB (in multiple ranges)
Range gain	x1, x10, x100, x1000
Calibration	By level or sensor sensitivity entry
Units	m/s ² , cm/s ² , ft/s ² , in/s ² , g, dB
Metrics for each mode:	
Vibration:	Arms, Amin, Amax, Aeq, Amp, Peak
Hand-arm:	Arms, Amin, Amax, Aeq, Amp, Peak, A(1), A(2), A(4), A(8), A(8) AET
Whole-body:	Arms, Amin, Amax, Aeq, Amp, Peak, CFmp, CF, VDV
Frequency weighting	
Vibration	Ws (Severity), Fa (0.4 Hz to 100 Hz), Fb (0.4 Hz to 1250 Hz), Fc (6.3 Hz to 1250 Hz)
Hand-arm	Wh
Whole-body	Wb, Wc, Wd, We, Wg, Wj, Wk, Wb
Setups	Store up to 10 user setups
Memory	100 measurements, 1 min to 99 hr
Time history	120 samples of Arms & PEAK at a period of 1, 2, 5, 10, 20, 30, 60 sec
Interface	USB (with DVX008A USB to DB9M Serial Adaptor) RS-422/RS-232 serial interface; modem mode
Printout	Custom 3 line header, data and time history
Outputs for each channel	
AC	Weighted or band-limited
DC	rms, min, max, peak, sum RMS, sum max, sum min, sum peak
Peak	± 0.5 dB accuracy
Power	(2) AA batteries (IEC Type LR6) <i>Batteries included</i>
Weight	300 gm (10.6 oz)
Dimensions	1.1 x 3.3 x 6.0 in (28 x 84 x 152 mm)
Standards met	ISO 8041:2005, 2631-1:1997, 2631-2:1989, 2631-4:2001, 5349-1:2001, and 5349-2:2001, ANSI 2.70-2006 plus it provides the whole-body frequency weighting Wg specified in the British Standard BS 6841:1987. CE compliant.

Available Configurations

AVAILABLE LANGUAGES	
STANDARD:	English, Spanish, German, and Italian.
HVM100-OPT2:	English, German, Portuguese and Czech.
HVM100-OPT3:	English, German, Italian and French
HVM100-OPT4:	English, German, Dutch and French.

Optional Accessories

ADP080	Hand accelerometer adaptor "T" bar
ADP081	Handle accelerometer adaptor, straight bar
ADP082	Clamp accelerometer adaptor, mounting block with clamp
ADP063	Palm accelerometer adaptor
ADP064	HVM100 adaptor kit includes hand, handle, clamp & palm adaptors
CBL006	Serial interface cable for HVM100. Used to connect to a PC
CCS020:	HVM100 Hard shell carrying case
HVM100-ACC	Accessories include one each: CBL006 RS-232 Computer interface cable, CBL124 AC/DC Output cable, CCS020 HVM100 Hard shell carrying case, PSA027 HVM100 Power supply, SWWBLAZE® Analysis software for HVM100.
394C06	The 394C06 provides a controlled vibration level for verifying sensitivity of accelerometers of up to 85 grams in weight.
PSA027	90 to 264V to 12V switching power supply for HVM100
SEN040F-CBL	Triaxial accelerometer, 1 mV/g ICP® & CBL158
SEN041F-CBL	Triaxial accelerometer, 10 mV/g ICP® & CBL158. The SEN041F has an internal filter, which helps attenuate high frequency vibrations before they can overload the internal preamplifier in the accelerometer internal filter, which helps attenuate high frequency vibrations before they can overload the internal preamplifier in the accelerometer
SEN023-CBL	Single axis accelerometer, 1 mV/g ICP® & CBL120
SEN024-CBL	Single axis accelerometer, 10 mV/g ICP® & CBL120
SEN025-CBL	Single axis accelerometer, 100 mV/g ICP® & CBL120a
SEN026-CBL	Triaxial palm accelerometer, 10 mV/g ICP® & CBL125
SEN027-CBL	Seat pad accelerometer, triaxial & CBL122
SWW_BLAZE:	Dosimetry software for HVM100 and Spark® family instruments

Available Configurations (partial listing, consult factory)

HVM100-ALL-40:	Hand-arm & whole-body vibration kit includes HVM100, HVM100-ALL, 1 mV/g accelerometer (SEN040F), seatpad accelerometer (SEN027), handle adaptor (ADP081), cables (CBL006, DVX008A, CBL158), case (CCS028), and Blaze® software.
HVM100-ALL-41:	Hand-arm & whole-body vibration kit includes HVM100, HVM100-ALL, 10 mV/g accelerometer with filter (SEN041F), seatpad accelerometer (SEN027), handle adaptor (ADP081), cables (CBL006, DVX008A, CBL158), case (CCS028), Blaze® software.
HVM100-ALL-26	Hand-arm & whole body vibration kit includes HVM100, HVM100-ALL, accelerometer (SEN026), seatpad (SEN027), palm adaptor (ADP063), cables (CBL006, DVX008A, CBL125), case (CCS028), Blaze® software.

LARSON DAVIS

A PCB PIEZOTRONICS DIV.

3425 Walden Avenue, Depew, NY 14043-2495 USA

Toll Free in USA 888-258-3222

Fax 716-926-8215 E-mail sales@larsondavis.com

Web Site www.larsondavis.com

ISO 9001:2000 CERTIFIED

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LD-HVM100 IHV-0808

Printed in U.S.A.

For environmental noise monitoring and building acoustics, **Larson Davis** offers a full line of instruments, accessories and software. For personal noise and vibration exposure monitoring, Larson Davis complements this with sound level meters, personal noise dosimeters, human vibration meters, audiometric calibration systems and hearing conservation programs.

Visit www.larsondavis.com to locate your nearest sales office



APPENDIX B





FIELD VIBRATION MEASUREMENT DATA

Project: Metro Wesside Mod 4

Job #: 27940 13.1

SITE IDENTIFICATION: V-1 OBSERVER(s): R Greene K Keller
 START DATE & TIME: 1430 11-5-08 END DATE & TIME: 11-5-08 1645
 ADDRESS: S/E Corner of New Hampshire and 5th St (3300 W)
next to 3300 5th St. GPS: 34° 04' 48.8" N 118° 17' 49.5" W

Measurement ID

INSTRUMENT: **LD HVM-100** SERIAL #: **00227**
 TRANSDUCER: **PCB 393B04** SERIAL #: **23354**
 MOUNTING METHOD: **STUD & SEISMIC MASS MAGNETIC ADHESIVE OTHER:**
 CALIBRATION: from accel cal chart Cal Level: 1g Cal Offset Check:
 SETUP: Z axis Gain: 60dB BW: 0.4-100 Avgs: 1sec Win: Lin Units: in/sec Lin Scale:
 MODE: Vibration velocity rms

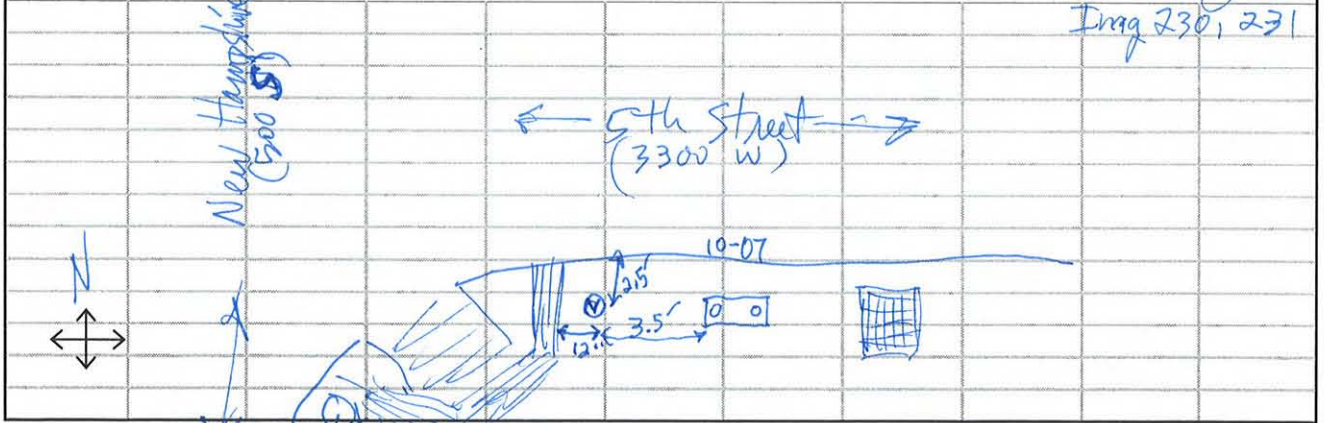
ID	File #	Start	End Time	Comments (incl. gain & # avgs if different than above)
		1515	1518	.00072 - .00066 ft/sec .00057 ft/sec .0010 ft/sec
<u>1</u>	<u>2</u>	<u>1519</u>	<u>1521</u>	<u>ambient w/ light traffic</u>
	<u>3 etc.</u>	<u>1521</u>	<u>1621</u>	<u>w/ trains NB & SB</u> .00365 in/sec typical .011 in/sec @ 1651 Hz .009 in/sec @ 1605 .00581 in/sec .00230 in/sec @ 1612 Hz

Vibration Measurements

PRIMARY SOURCE: TRAFFIC RAIL CONSTRUCTION INDUSTRIAL AMBIENT OTHER
 OTHER/DESC:
 OTHER VIB SOURCES: distant TRAFFIC / distant RAIL / distant CONSTRUCTION
 OTHER:

Source Info

SURFACE: FLAT ROLLING DIRT CONCRETE ASPHALT OTHER:
 SUBSURFACE: UNKNOWN SOIL ROCK OTHER: SOIL TYPE:
 OTHER COMMENTS / SKETCH:



Description / Sketch





CAUTION

CAUTION

CAUTION

CAUTION

CAUTION

5078
213-383-7557



CAUTION

CAUTION

CAUTION

CAUTION

CAUTION

CAUTION

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CAUTION

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CAUTION

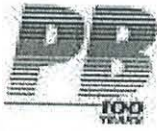
CAUTION

CAUTION

CAUTION

GOODYEAR

대한 자동차



FIELD VIBRATION MEASUREMENT DATA

Project: Metro Wesside Mod 4

Job #: 27940 13.1

SITE IDENTIFICATION: V-2 OBSERVER(s): K. Keller & R. Greene
 START DATE & TIME: 11-6-09 1430 END DATE & TIME:
 ADDRESS: North Side Valleyhart Dr ~110 feet east of Willow Crest Ave
(10600 W) (4800 N)
 "The Island Neighborhood" GPS:

Measurement ID

INSTRUMENT: LD HVM-100 SERIAL #: 00227
 TRANSDUCER: PCB 393B04 SERIAL #: 23354
 MOUNTING METHOD: STUD & SEISMIC MASS MAGNETIC ADHESIVE OTHER:
 CALIBRATION: Cal Level: 1019 mV/g Cal Offset Check:
 SETUP: Velocity Gain: 60 BW: 0.1-100 Avgs: Win: Lin Units: in/sec Lin Scale:
 MODE: Vibration 0.1-100 Hz

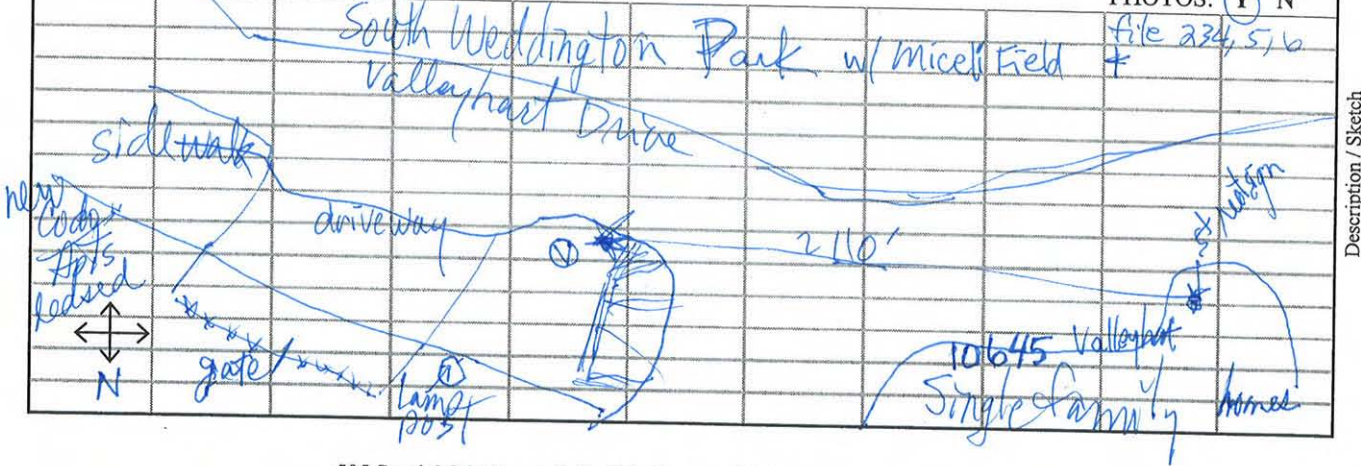
ID	File #	Start	End Time	Comments (incl. gain & # avgs if different than above)
	<u>01</u>	<u>15:13</u>	<u>16:13</u>	<u>[16:12 hrs car entering driveway overloaded vibration meter briefly]</u>
	<u>etc.</u>			

Vibration Measurements

PRIMARY SOURCE: TRAFFIC RAIL CONSTRUCTION INDUSTRIAL AMBIENT OTHER
 OTHER/DESC: few
 OTHER VIB SOURCES: distant TRAFFIC / distant RAIL / distant CONSTRUCTION
 OTHER:

Source Info

SURFACE: FLAT ROLLING DIRT CONCRETE ASPHALT OTHER:
 SUBSURFACE: UNKNOWN SOIL ROCK OTHER: SOIL TYPE:
 OTHER COMMENTS / SKETCH:



Description / Sketch



FIELD VIBRATION MEASUREMENT DATA

Project: Metro Westside Mod 4

Job #: 27940 13.2

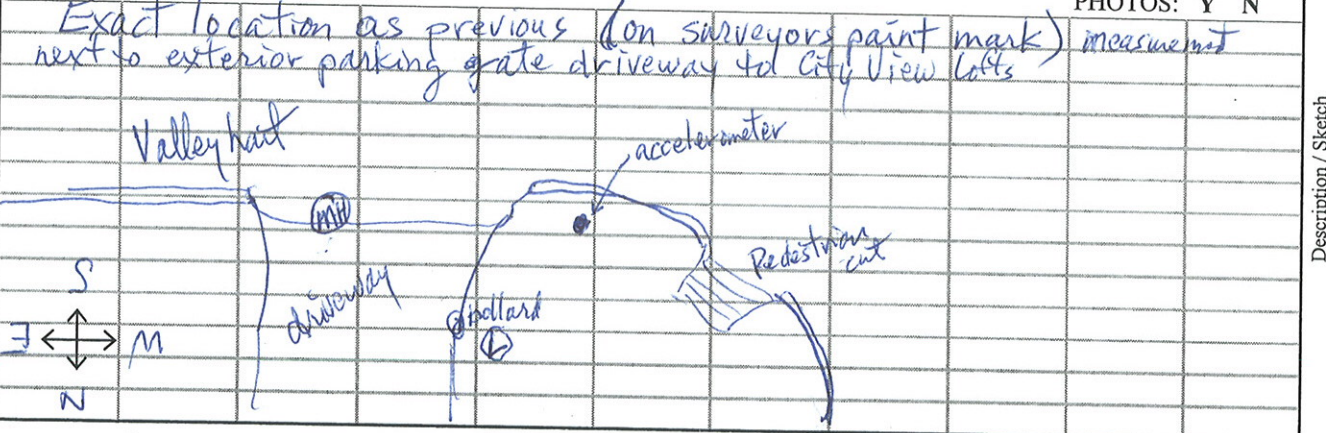
SITE IDENTIFICATION: Valley Hart Dr. V-2 OBSERVER(s): K. Keller & R. Greene & Loetterle
 START DATE & TIME: 2-25-09 1300 END DATE & TIME: 2-25-09 1500
 ADDRESS: 4055 Lankershim Blvd (actual property address)
"City View Lofts" GPS:

INSTRUMENT: LD HVM-100 SERIAL #: 00227 ✓
 TRANSDUCER: PCB 393B04 SERIAL #: 233461 ✓
 MOUNTING METHOD: STUD & SEISMIC MASS MAGNETIC ADHESIVE OTHER:
 CALIBRATION: Done Cal Level: 1g rms Cal Offset Check:
 SETUP: Velocity Gain: 60 BW: 0.4-1250 Hz Avgs: 1sec Win: Lin Units: Lin Scale:
 MODE:

ID	File #	Start	End Time	Comments (incl. gain & # avgs if different than above)
		1329	1438	1332 UPS TK passby 1335 auto passby 1337+ 2 auto passby 1340 2 passby (auto + SUV) 1341 Uhaul passby 1343 small van 1344 auto 1345 station wagon SUV 1347 small van pulling into driveway 1350 auto 1351+ tripped car 1355 auto 1358 van back out of driveway 1400 auto 1401 Van passby + auto 1402 auto + auto 1404 SUV enter driveway 1409 SUV passby 1412 SUV out of driveway 1413 2 SUV passby 1414 SUV passby 1419 SUV passby 1420+ auto passby 1422 2 auto + auto 1424 3 auto + 2 auto 1426 2 auto + mail truck 1428 SUV pull into driveway 1431 SUV passby 1432 auto passby 1433 auto into driveway 1436 auto

PRIMARY SOURCE: TRAFFIC RAIL CONSTRUCTION INDUSTRIAL AMBIENT OTHER 1437 3 auto passby
 OTHER/DESC:
 OTHER VIB SOURCES: distant TRAFFIC / distant RAIL / distant CONSTRUCTION
 OTHER:

SURFACE: FLAT ROLLING DIRT CONCRETE ASPHALT OTHER:
 SUBSURFACE: UNKNOWN SOIL ROCK OTHER: SOIL TYPE:
 OTHER COMMENTS / SKETCH:











Berendo Street

Catalina Street

New Hampshire Avenue

Vermont Avenue

6th Street

Wilshire/
Vermont Station

Shatto Place

V-3

Westmoreland Avenue

Wilshire Boulevard

Shatto Place

Westmoreland Avenue

Wilshire Place

Virgil Avenue

Commonwealth Avenue

7th Street

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M Metro

adidas Kids





Hillside Avenue

Fuller Avenue

Franklin Avenue

V-4

Camino Palmero Street

Hollywood Boulevard

1st Beat Avenue

El Cerrito Place

Sycamore Avenue

Orange Drive

Outpost Drive

Franklin Avenue

Hollywood/
Highland
Station

Google



7200

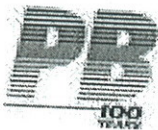
Surveying instrument display



NO PARKING

7200

adidas



FIELD VIBRATION MEASUREMENT DATA

Project: Metro Wesside Mod 4

Job #: 27940 13.1

SITE IDENTIFICATION: Wilshire / Park View OBSERVER(s): Kelber - Greene - Lotterle
 START DATE & TIME: 3-20-09 1430 END DATE & TIME: 3-20-09 1630
 ADDRESS: South east corner
MacArthur Park

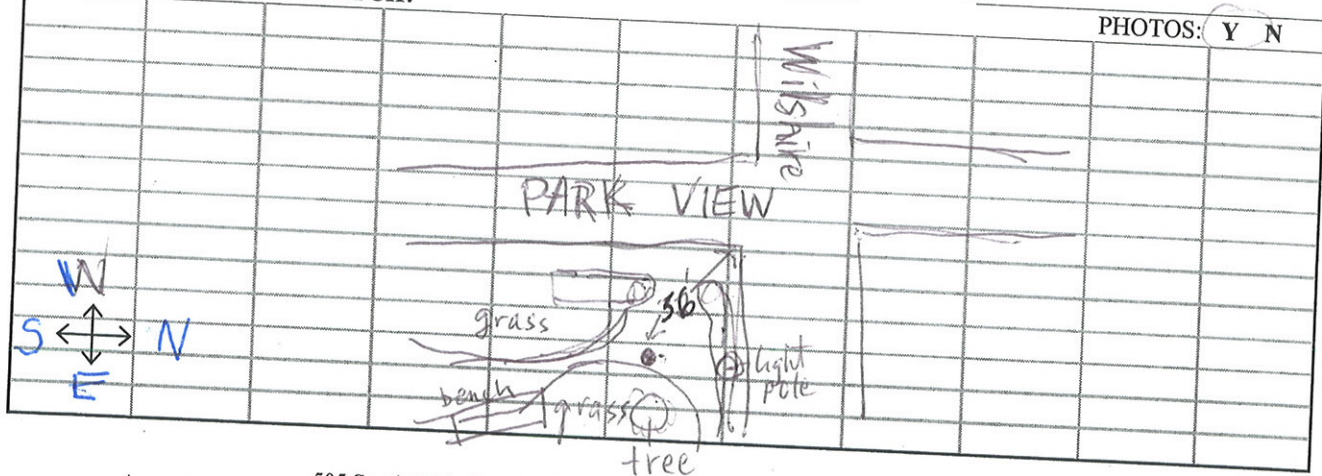
GPS:

INSTRUMENT: **LD HVM-100** SERIAL #: **00227**
 TRANSDUCER: **PCB 393B04** SERIAL #: **23354 23361**
 MOUNTING METHOD: **STUD & SEISMIC MASS** MAGNETIC ADHESIVE OTHER:
 CALIBRATION: Velocity Cal Level: 1g Cal Offset Check: OK
 SETUP: Gain: 60 BW: 0.4-1250 Hz Avgs: 1sec Win: Lin Units: ips Lin Scale:
 MODE:

ID	File #	Start	End Time	Comments (incl. gain & # avgs if different than above)
		1506	1606	1515 - Windy - 1530 or so
				1517 - skate boarder - 1518 HT + Metro bus 1519 Rapid
				1520 metro bus 1521 Foothill Transit Bus 1528 2 ^{SB} Metro
				Rapid Buses - noted @ 100 feet 1529 metro bus rapid
				1530 med TK WB Park View 1530 WB Metro Bus @ 100 feet
				1532 EB metro bus @ 100 feet 1533 EB Orange Bus
				1534 2 Orange buses 1536 Orange 1537 2 slow Metro Rapids
				1540 Child running 1543 WB Rapid bus 1545 EB Orange Metro local bus
				1546 FedEx HT EB 1549 Foothill Transit EB 1550 EB Rapid Bus
				1552 Orange bus + Rapid bus + Rapid bus 1554 EB Rapid Bus

PRIMARY SOURCE: **TRAFFIC RAIL CONSTRUCTION INDUSTRIAL AMBIENT OTHER**
 OTHER/DESC: 1555 WB Rapid
 OTHER VIB SOURCES: distant TRAFFIC / distant RAIL / distant CONSTRUCTION
 OTHER: @ approx 100 feet
all noted Rapid buses were articulated doubles

SURFACE: **FLAT ROLLING DIRT CONCRETE ASPHALT OTHER:**
 SUBSURFACE: **UNKNOWN SOIL ROCK OTHER:** SOIL TYPE:
 OTHER COMMENTS / SKETCH:

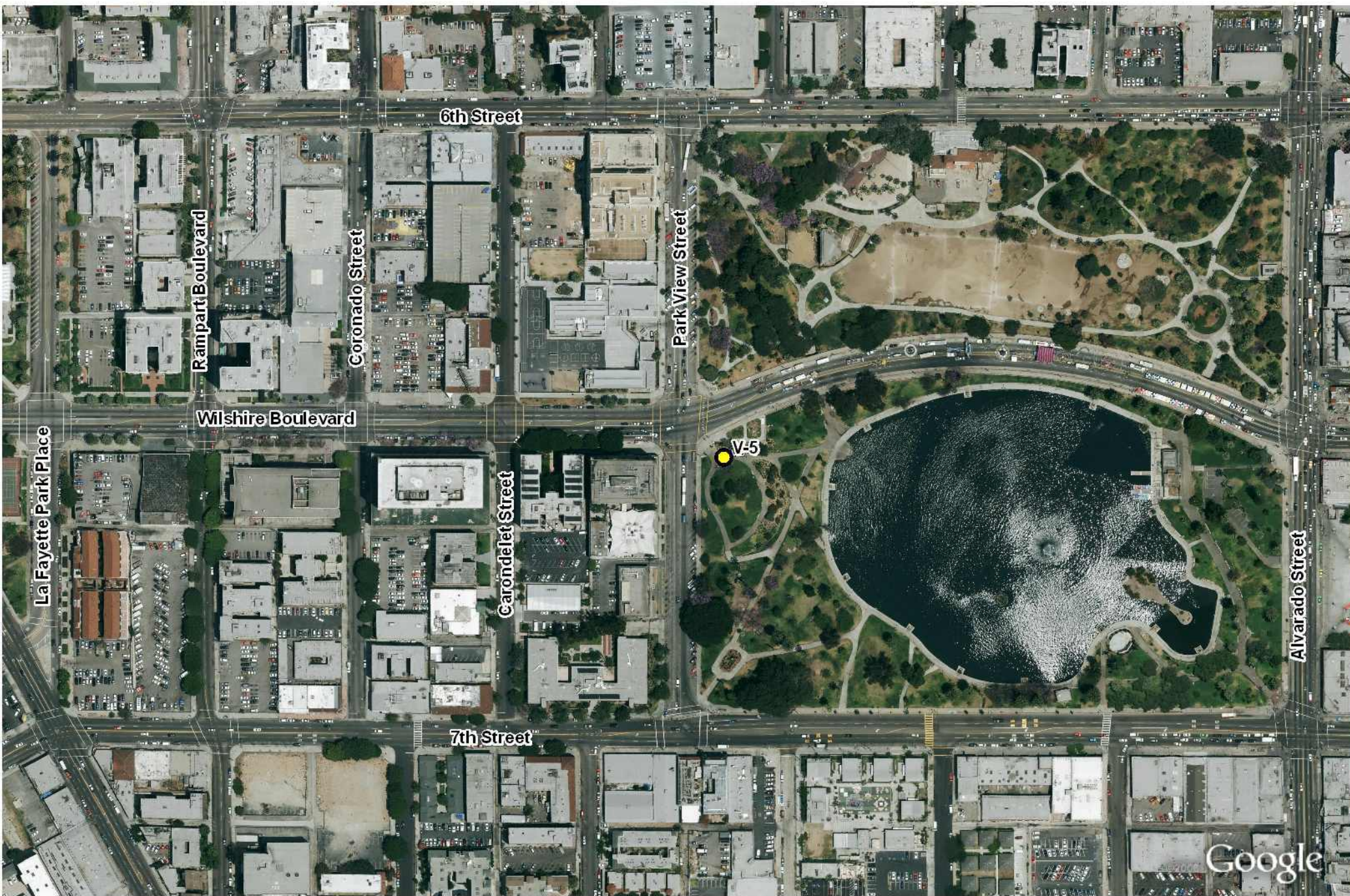


Measurement ID

Vibration Measurements

Source Info

Description / Sketch



La Fayette Park Place

Rampart Boulevard

Wilshire Boulevard

6th Street

Coronado Street

Carondelet Street

Park View Street

7th Street

Alvarado Street

V-5

Google





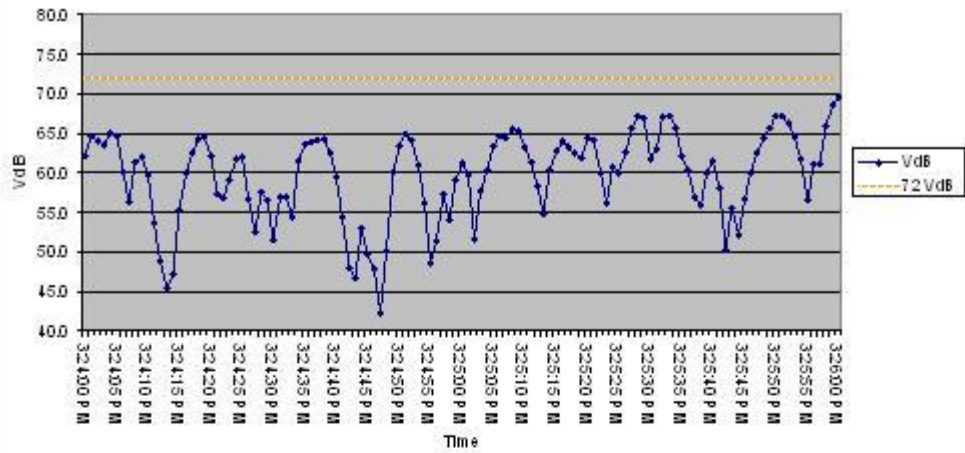


APPENDIX C

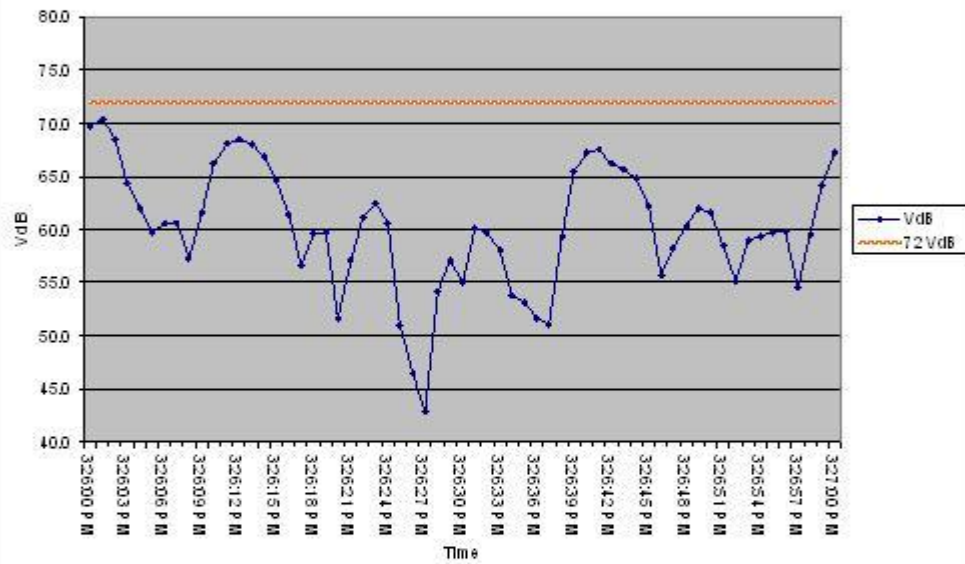


Site V-1 New Hampshire and 5th Street

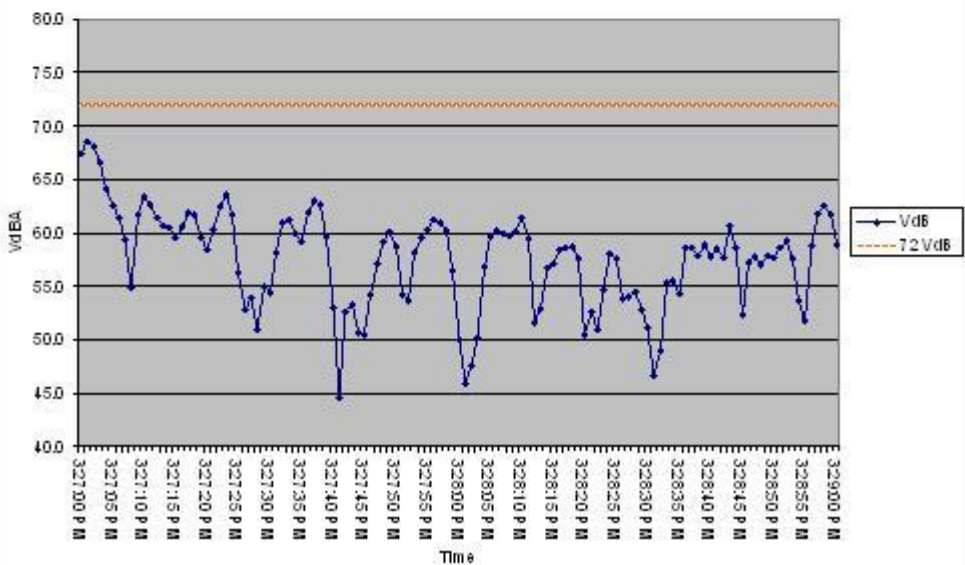
3:24 Northbound - Bottom Tunnel



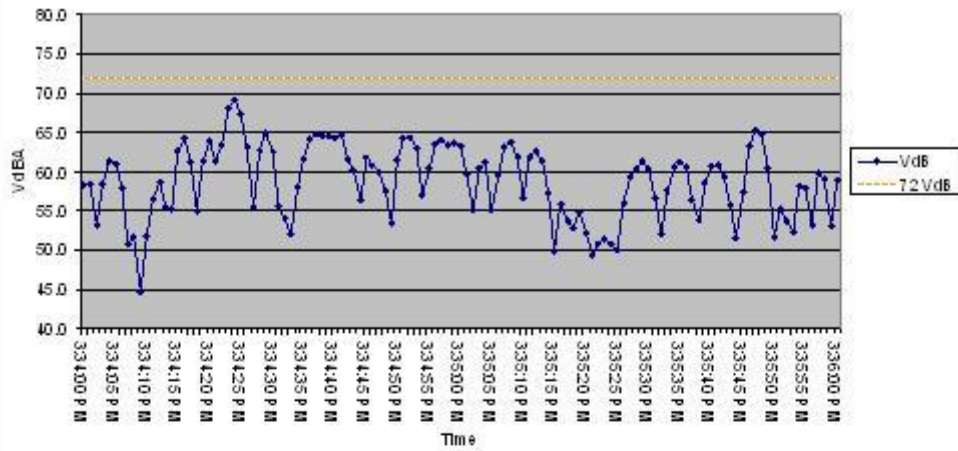
3:26 - 3:27 No Trains



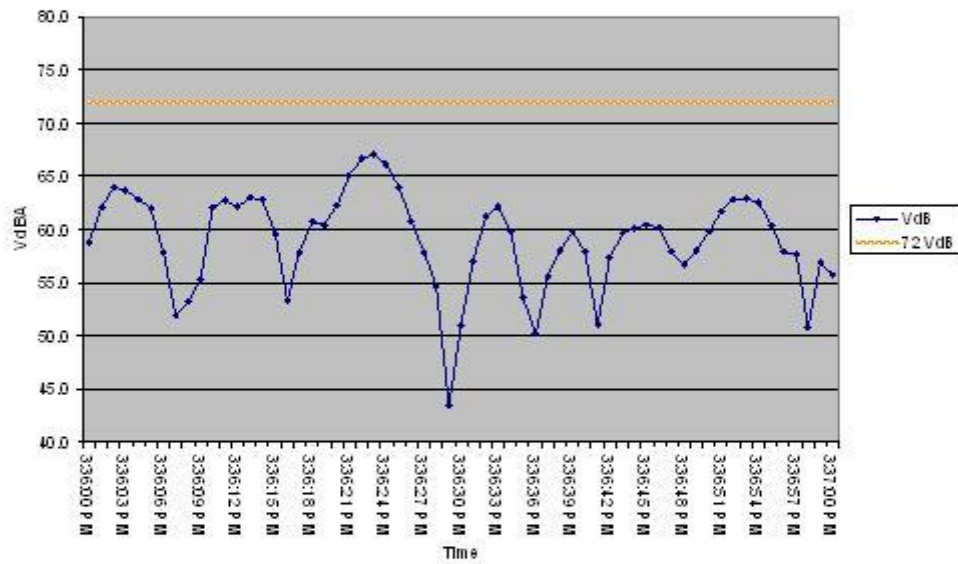
3:27 Southbound Train - Top Tunnel



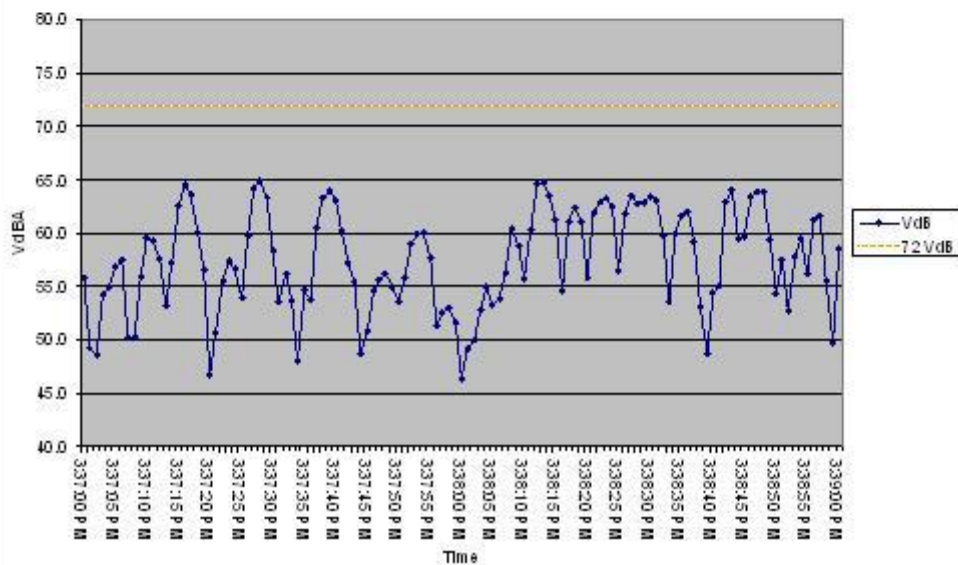
3:34 Northbound - Bottom Tunnel



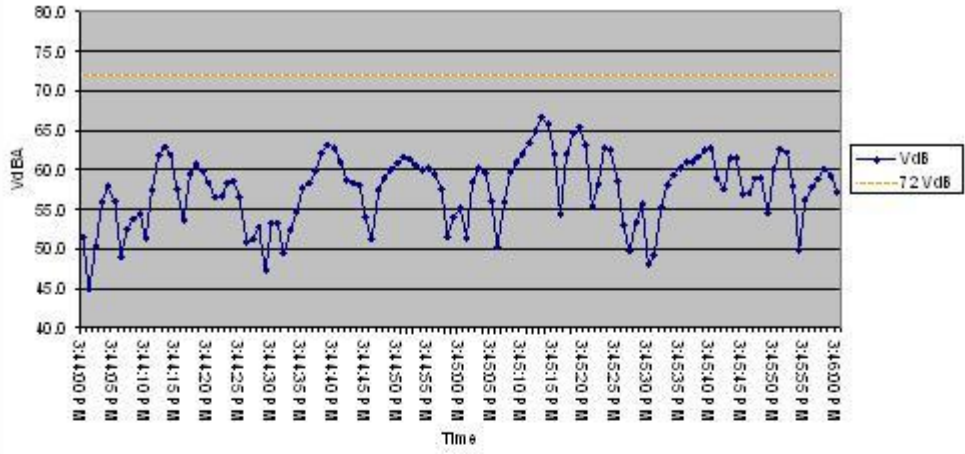
3:36 - 3:37 No Trains



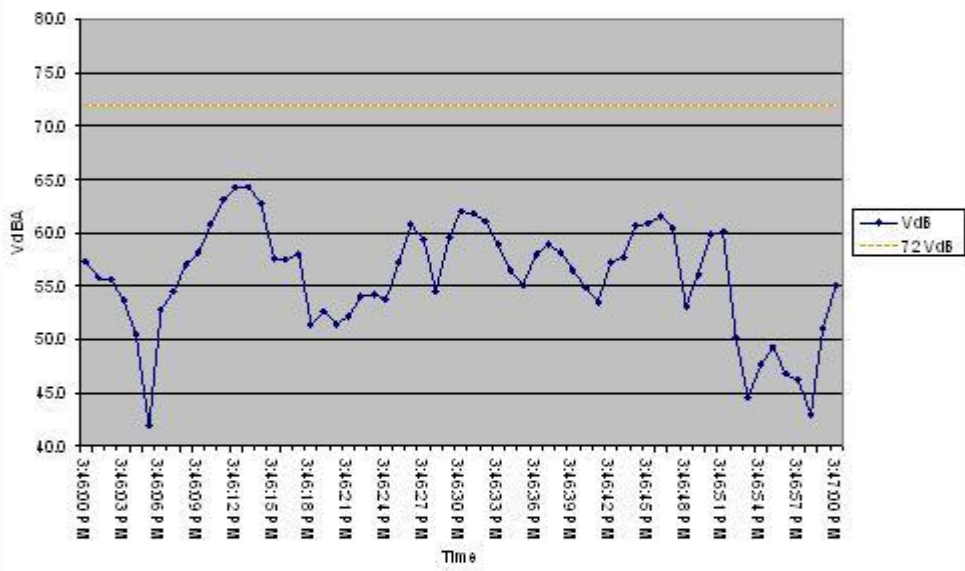
3:37 Southbound Train - Top Tunnel



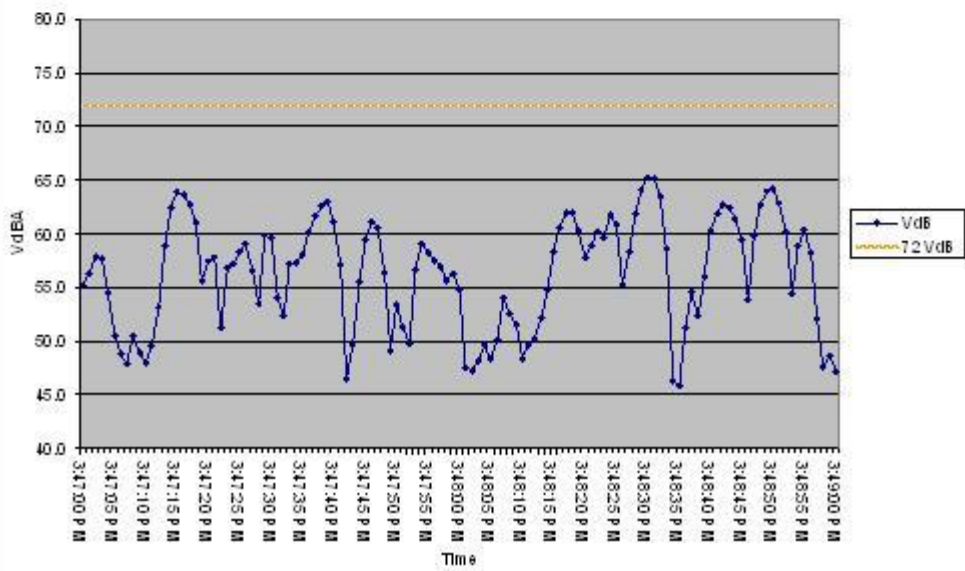
3:44 Northbound - Bottom Tunnel



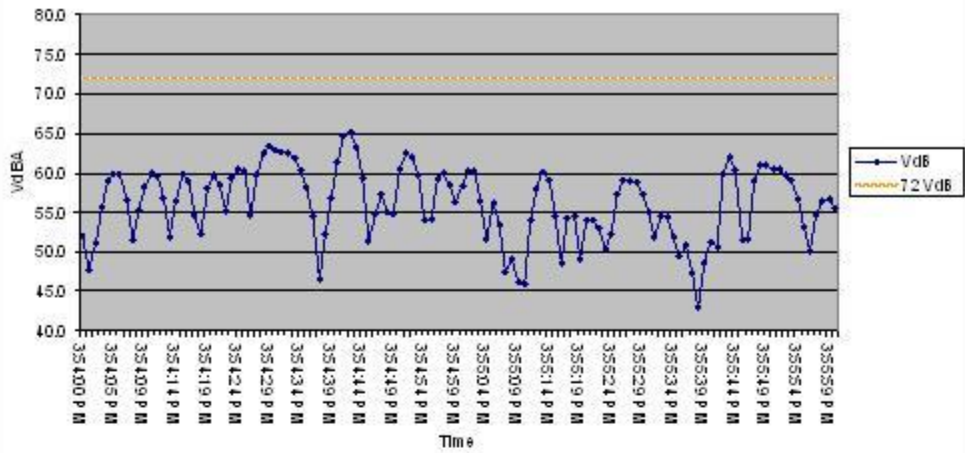
3:46 - 3:47 No Trains



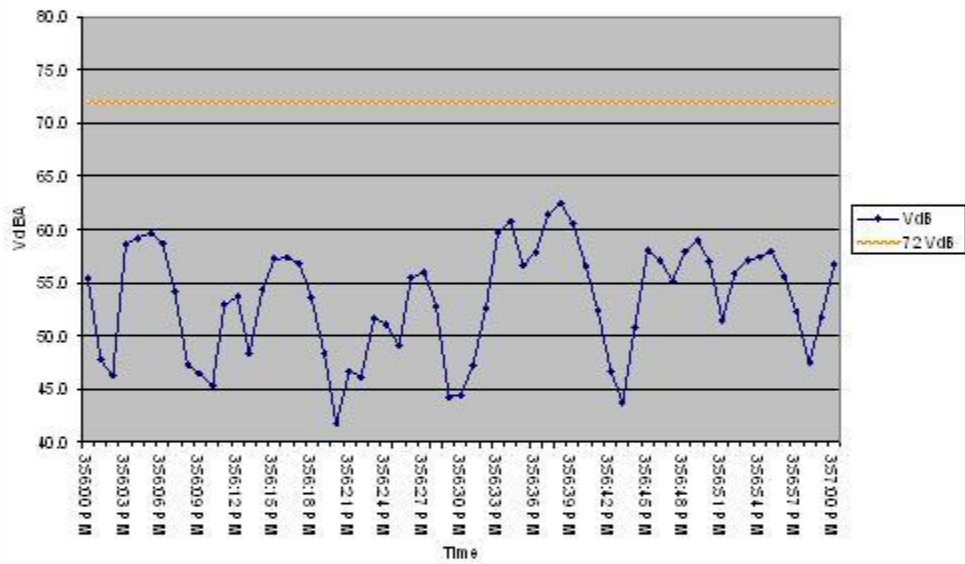
3:47 Southbound Train - Top Tunnel



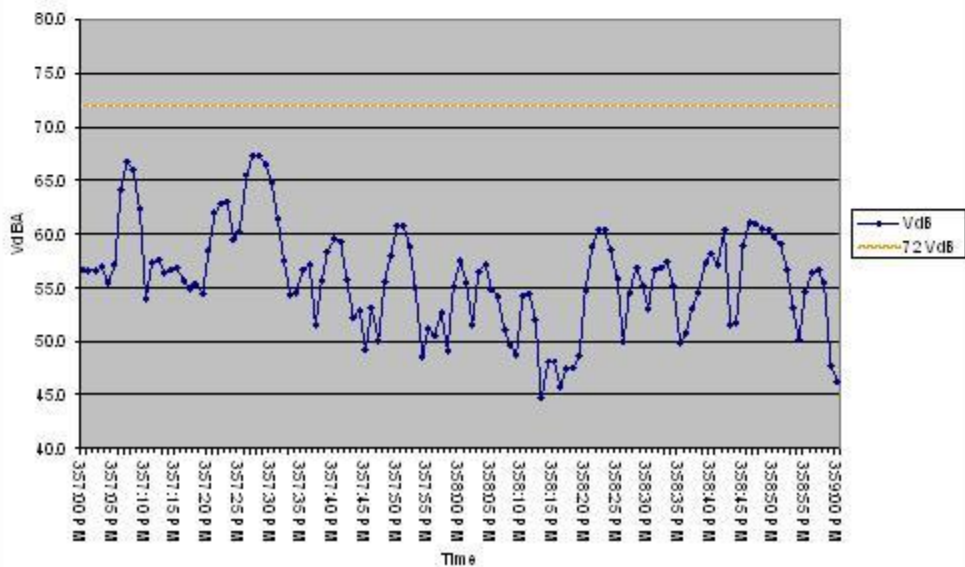
3:54 Northbound - Bottom Tunnel



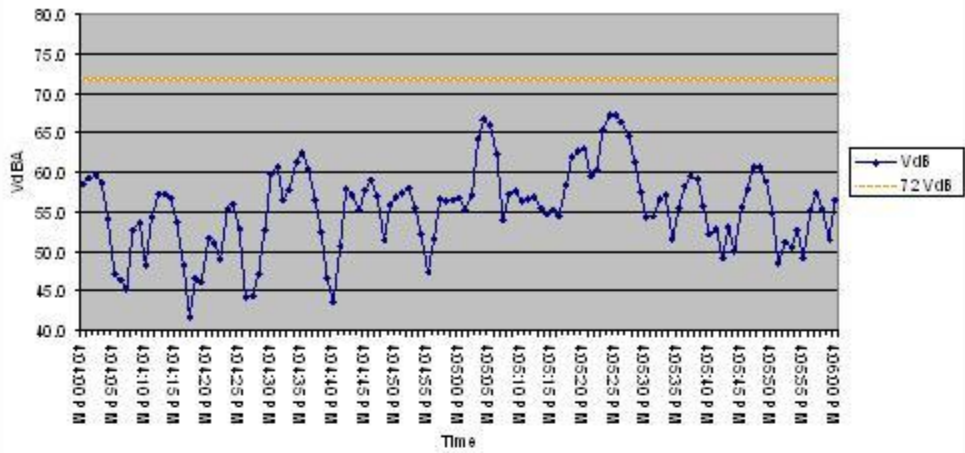
3:56 - 3:57 No Trains



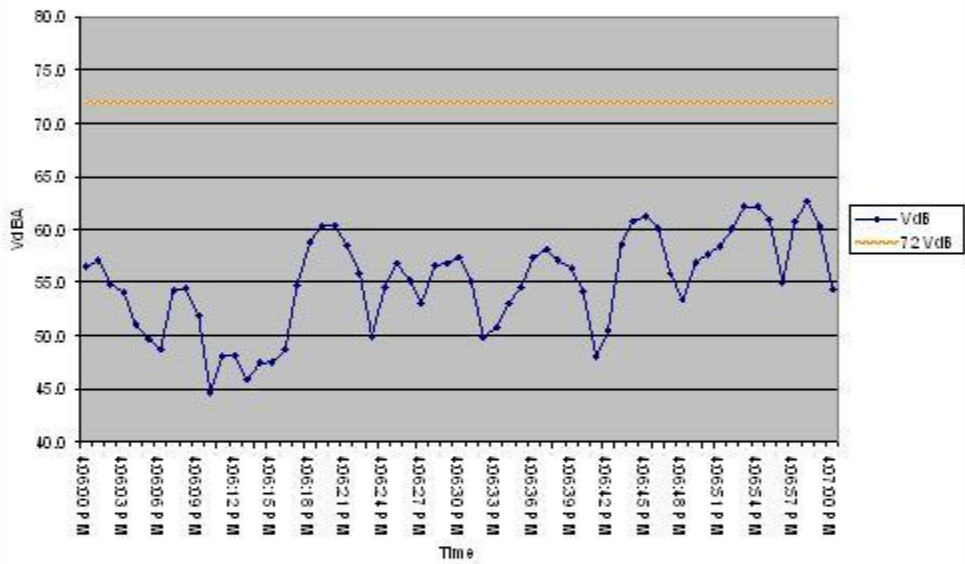
3:57 Southbound Train - Top Tunnel



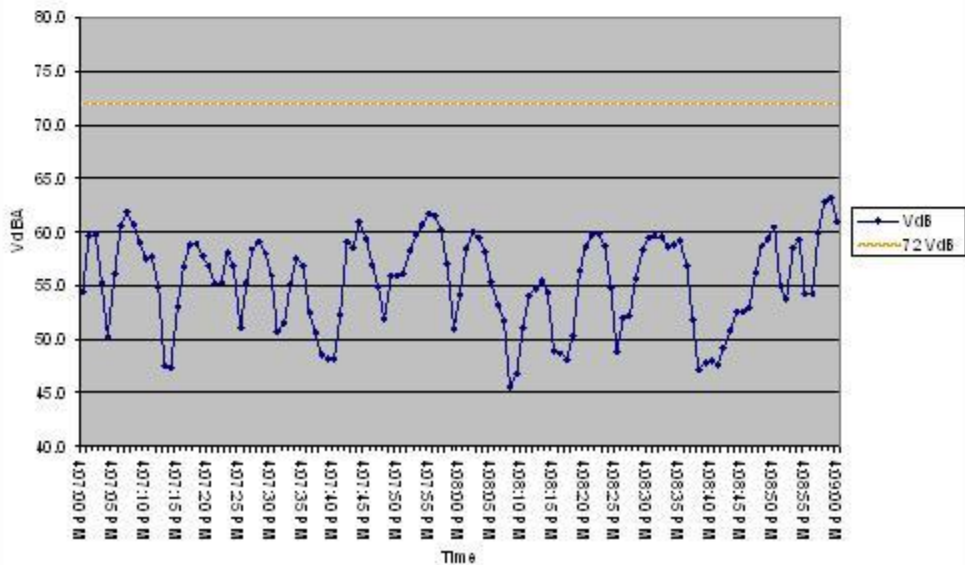
4:04 Northbound - Bottom Tunnel



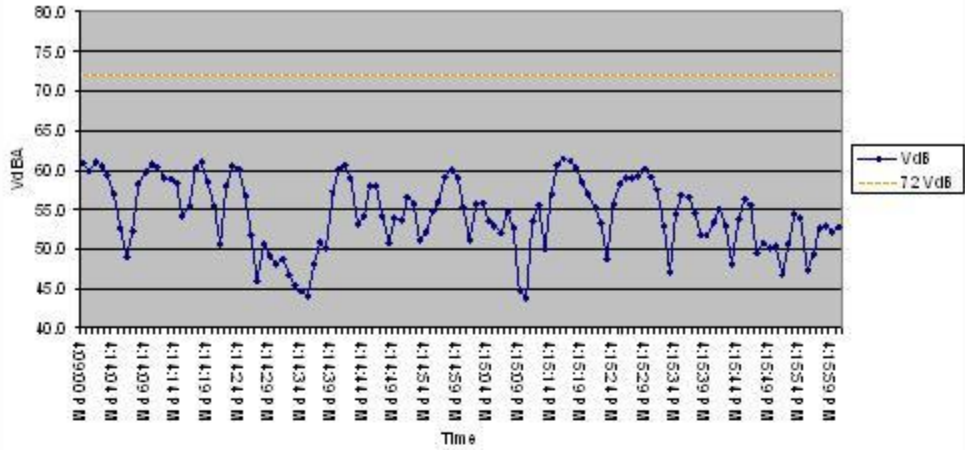
4:06 - 4:07 No Trains



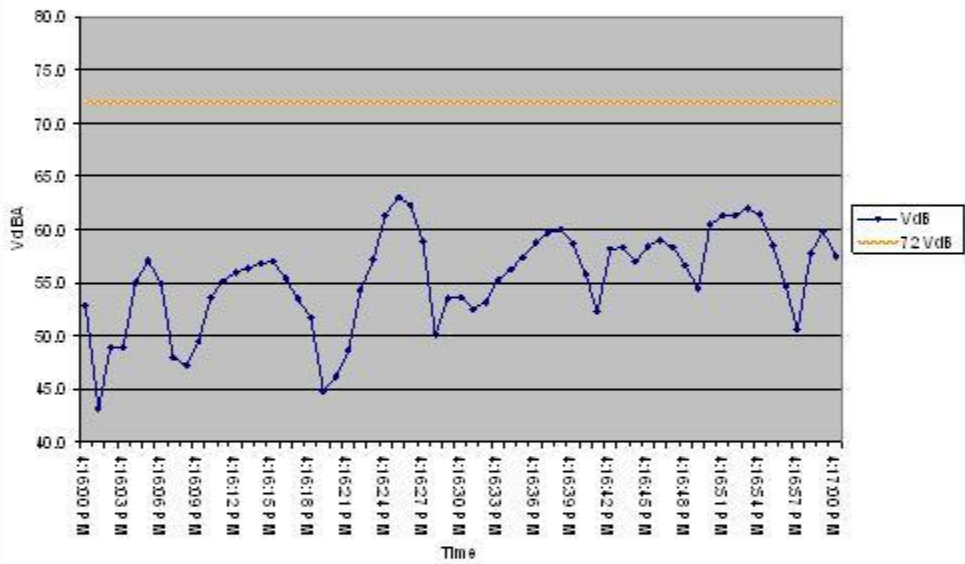
4:07 Southbound Train - Top Tunnel



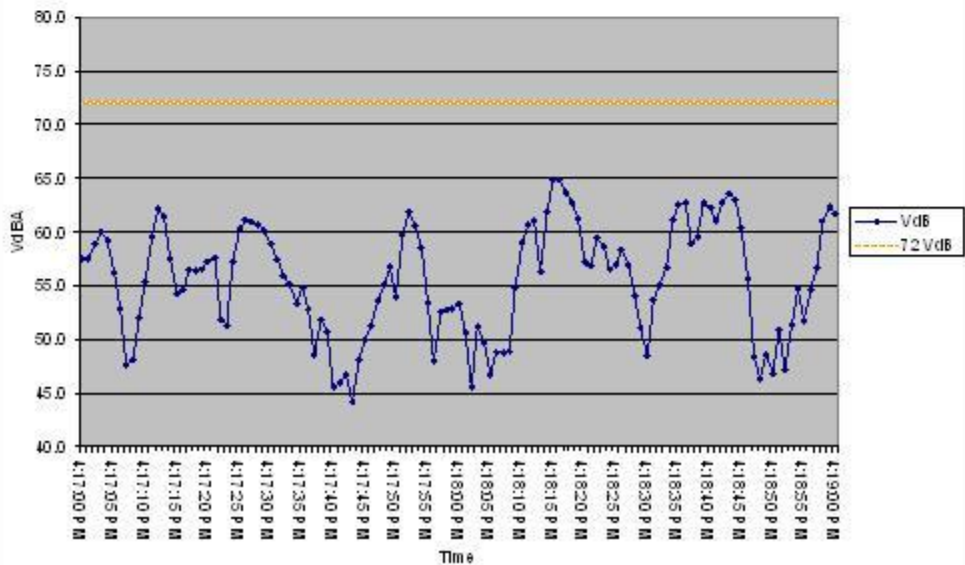
4:14 Northbound - Bottom Tunnel



4:16 - 4:17 No Trains

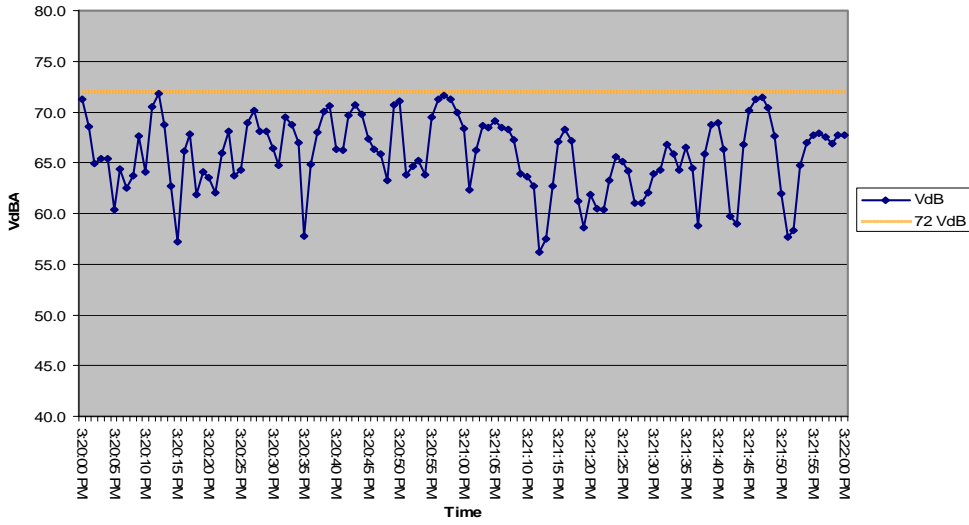


4:17 Southbound Train - Top Tunnel

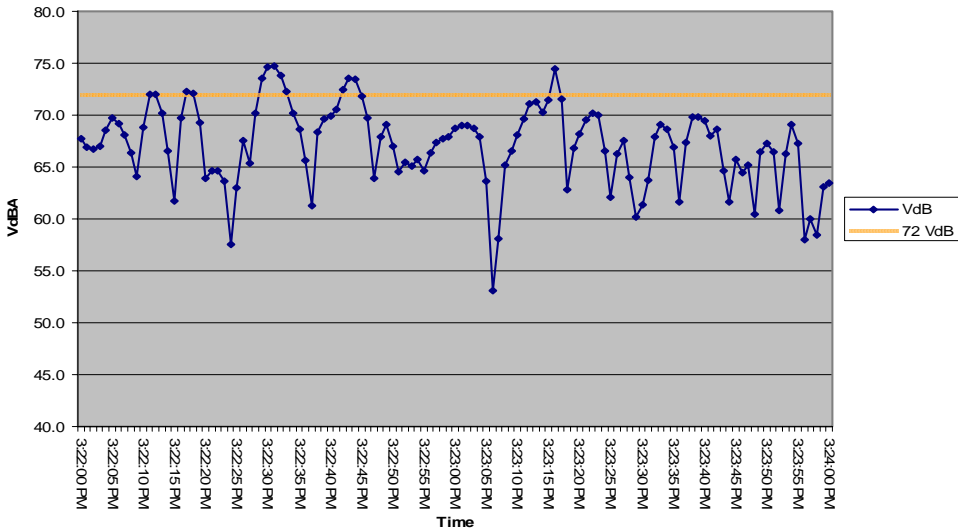


Site V-2 Valleyhart Drive

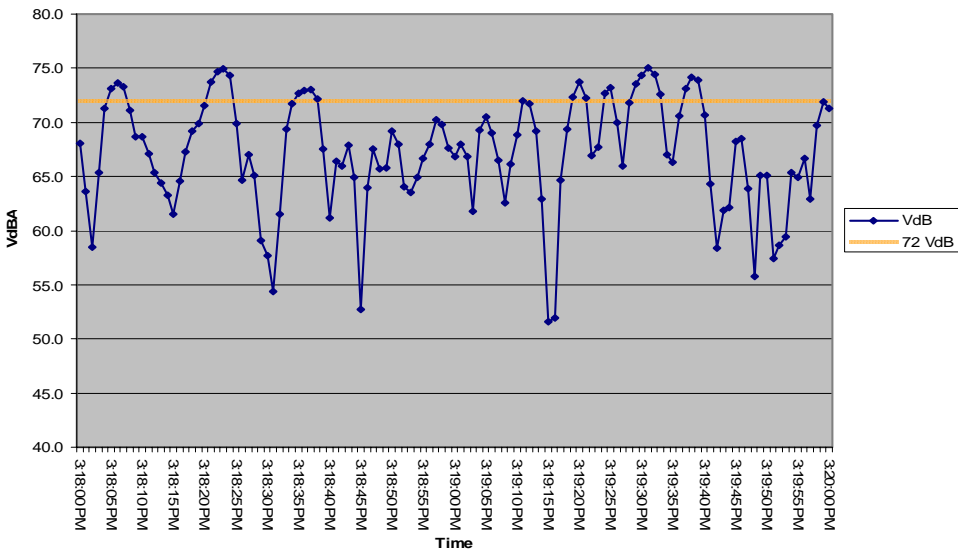
**3:20 Northbound Train Leaves Universal City
Arrives North Hollywood 3:22**



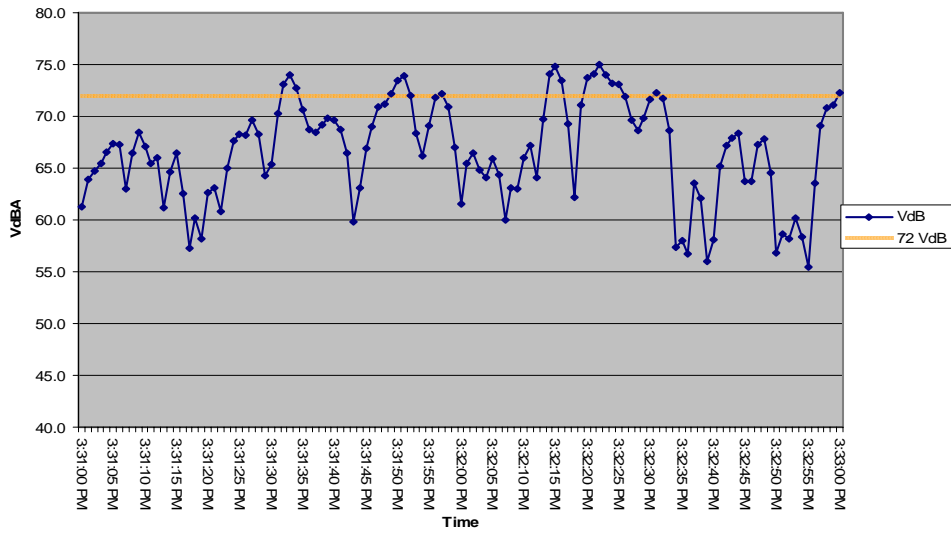
**3:22 Southbound Leaves North Hollywood
Arrives Universal City 3:24**



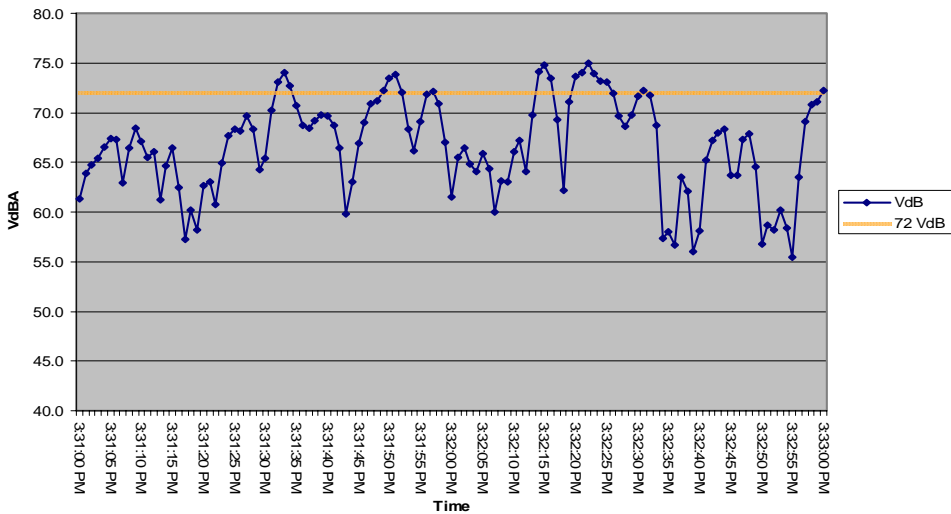
3:18 to 3:20 No Trains



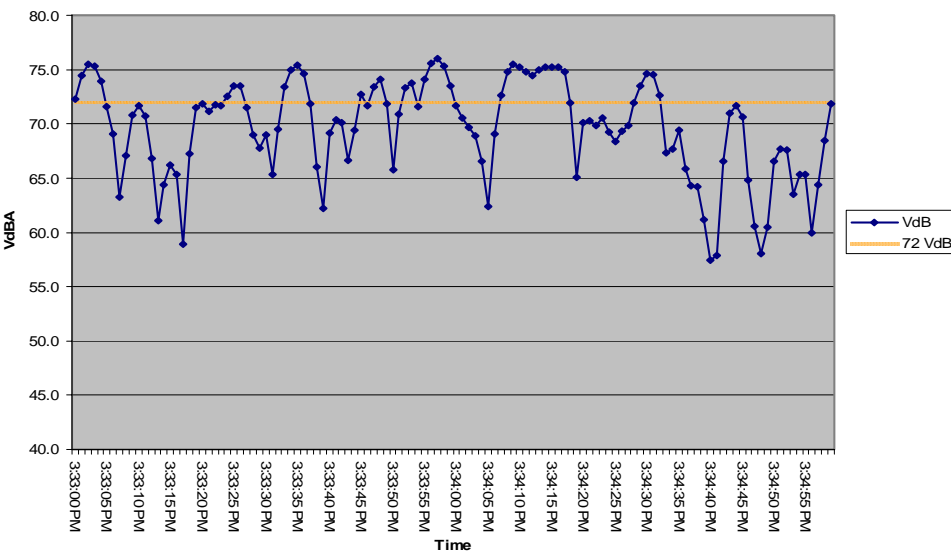
**3:31 Northbound Train Leaves Universal City
Arrives North Hollywood 3:33**



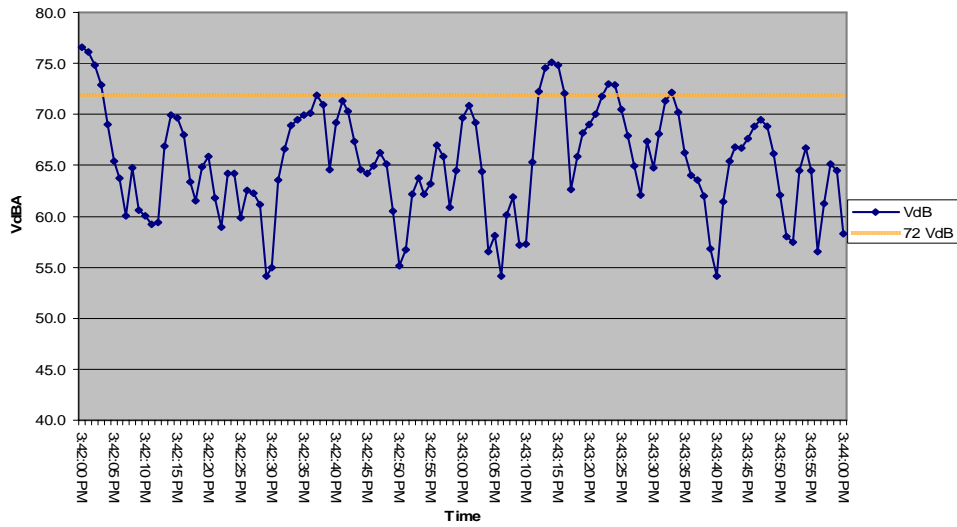
**3:31 Southbound Leaves North Hollywood
Arrives Universal City 3:33**



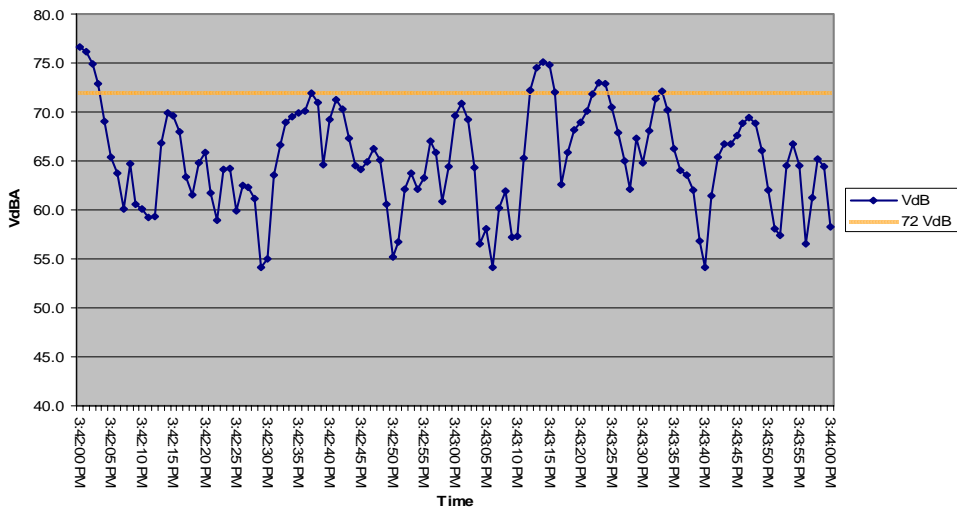
3:33 to 3:35 No Trains



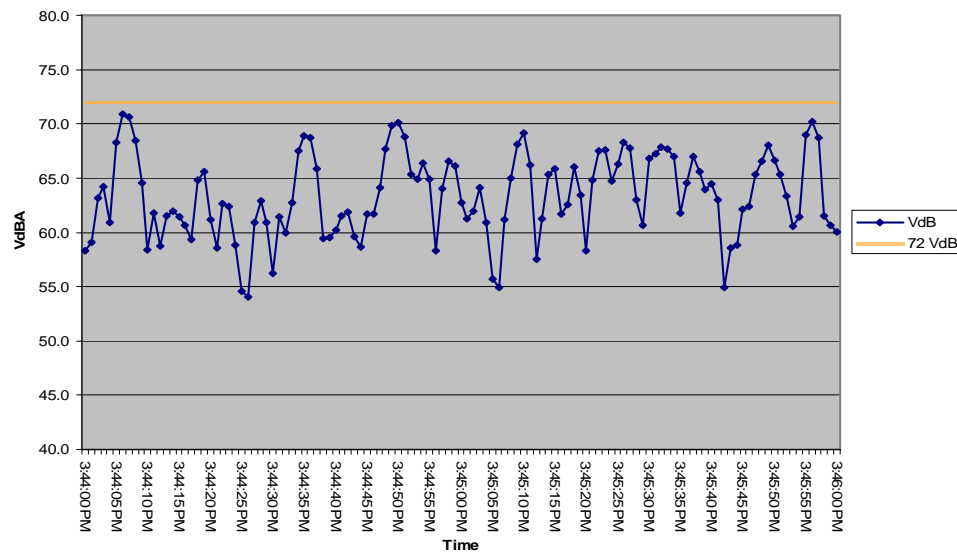
**3:42 Northbound Train Leaves Universal City
Arrives North Hollywood 3:44**



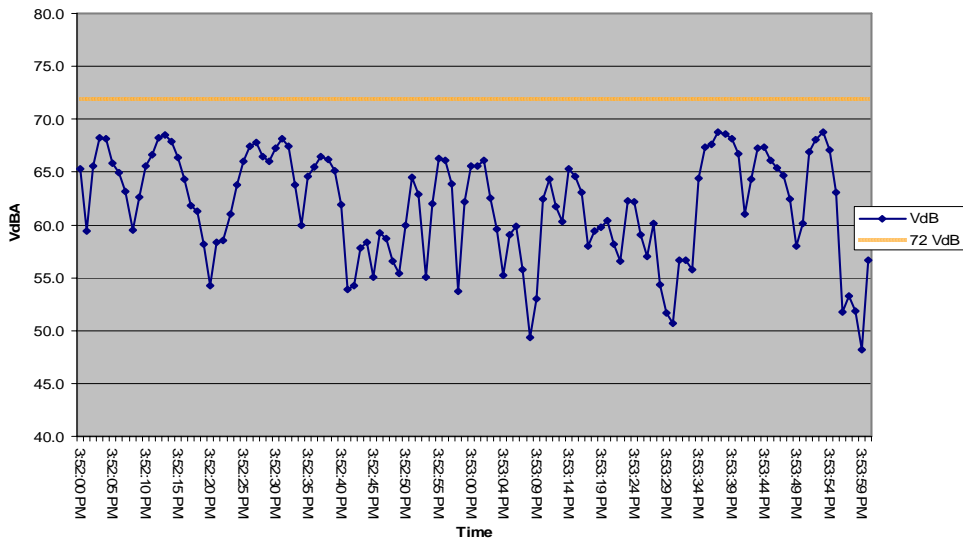
**3:42 Southbound Leaves North Hollywood
Arrives Universal City 3:44**



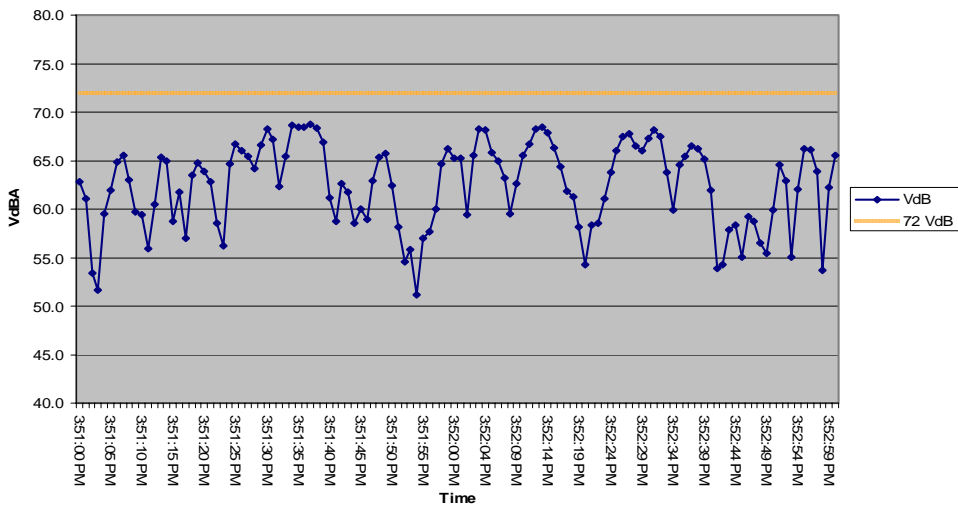
3:44 to 3:46 No Trains



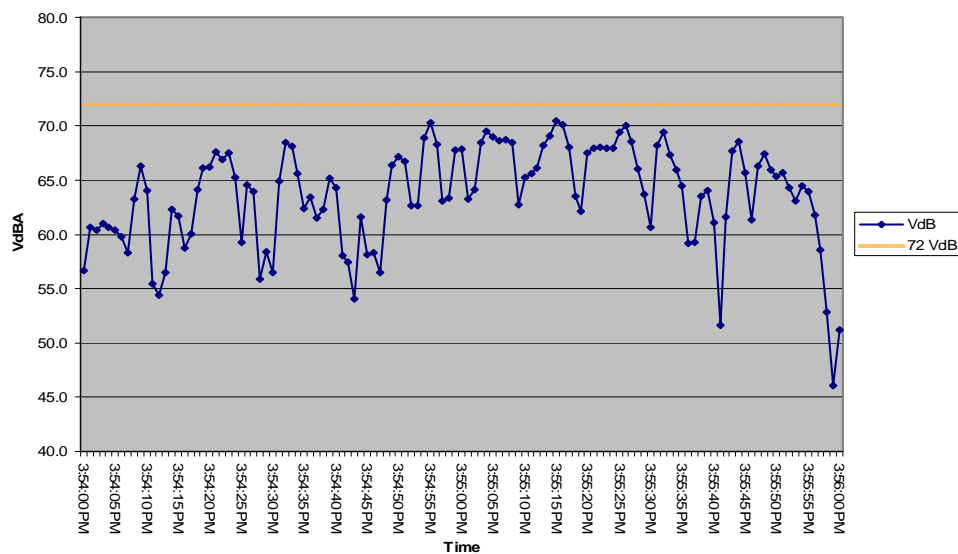
**3:52 Northbound Train Leaves Universal City
Arrives North Hollywood 3:54**



**3:51 Southbound Leaves North Hollywood
Arrives Universal City 3:52**

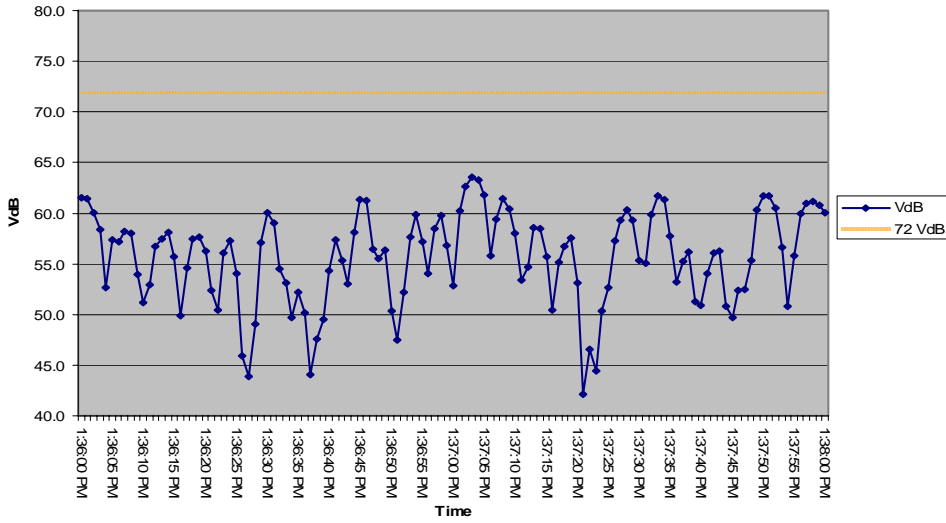


3:54 to 3:56 No Trains

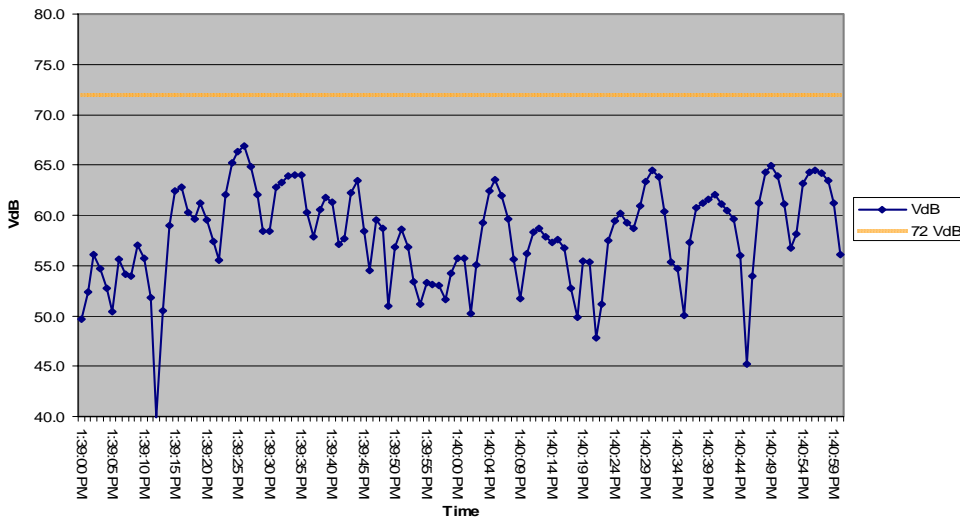


Site V-2S Valleyhart Drive

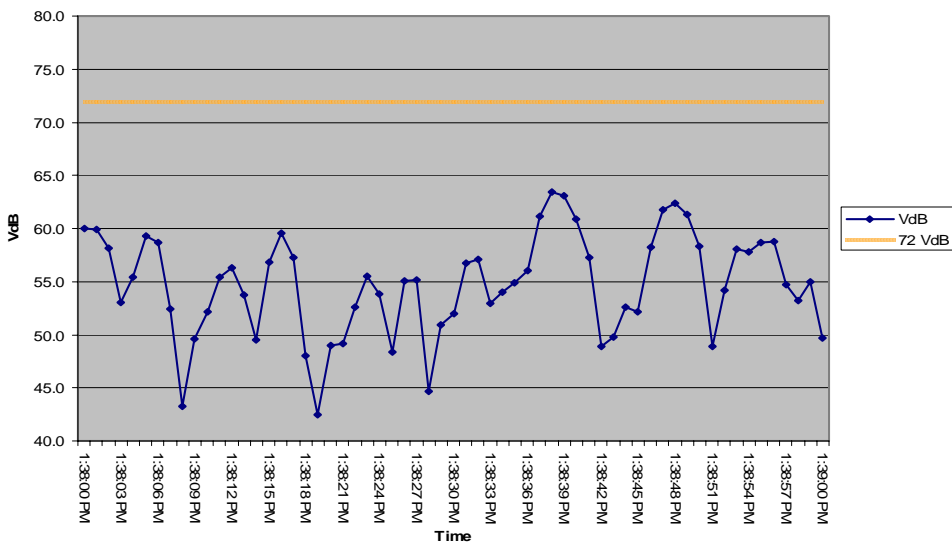
**1:36 Northbound Train Leaves Universal City
Arrives North Hollywood 1:38**



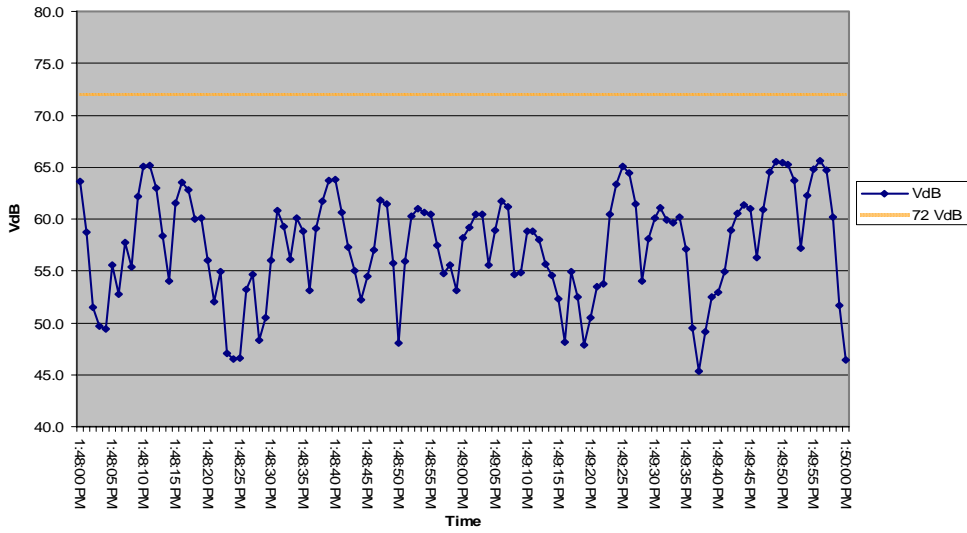
**1:39 Northbound Train Leaves Universal City
Arrives North Hollywood 1:41**



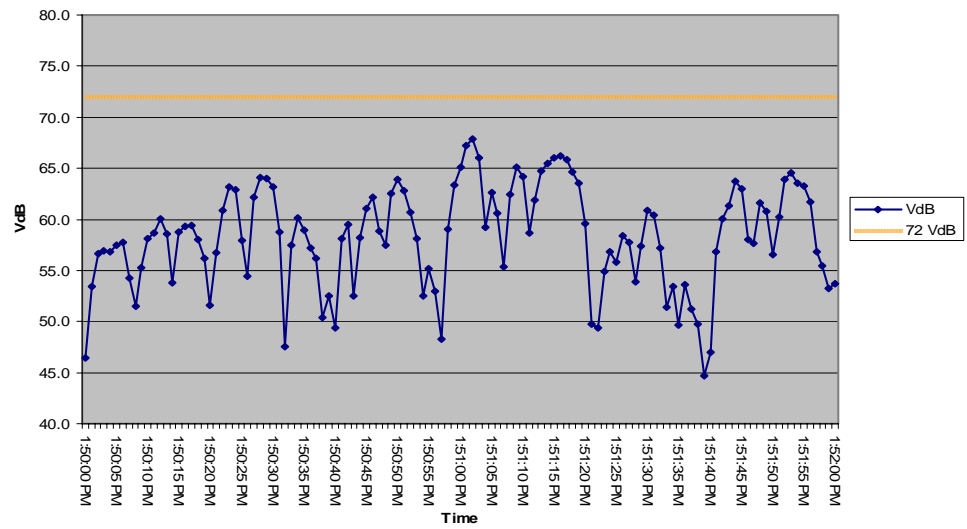
1:38 to 1:39 No Trains



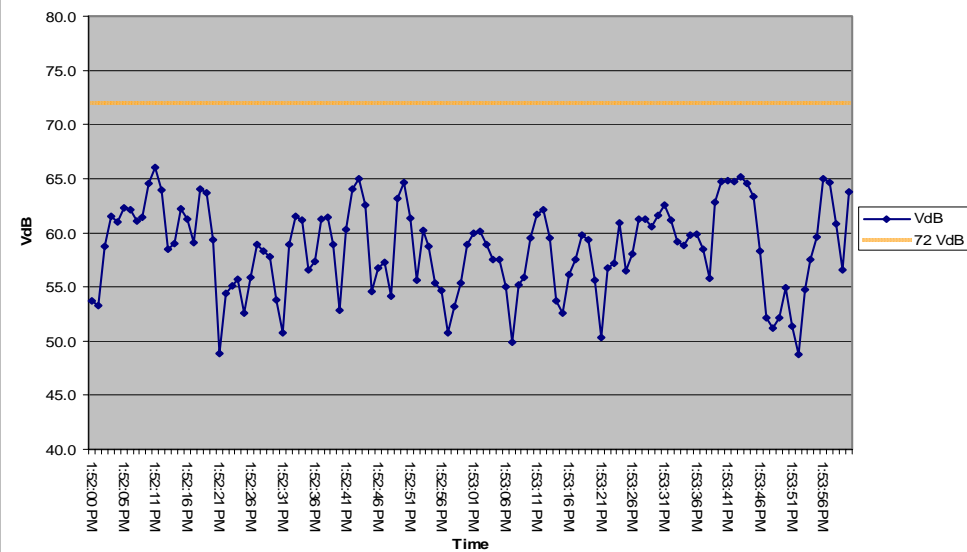
**1:48 Northbound Train Leaves Universal City
Arrives North Hollywood 1:50**



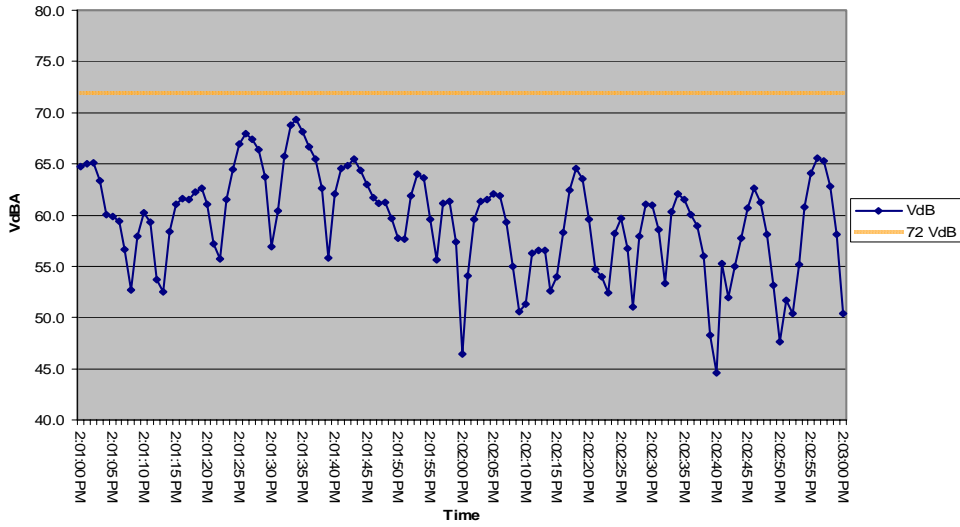
**1:50 Southbound Leaves North Hollywood
Arrives Universal City 1:52**



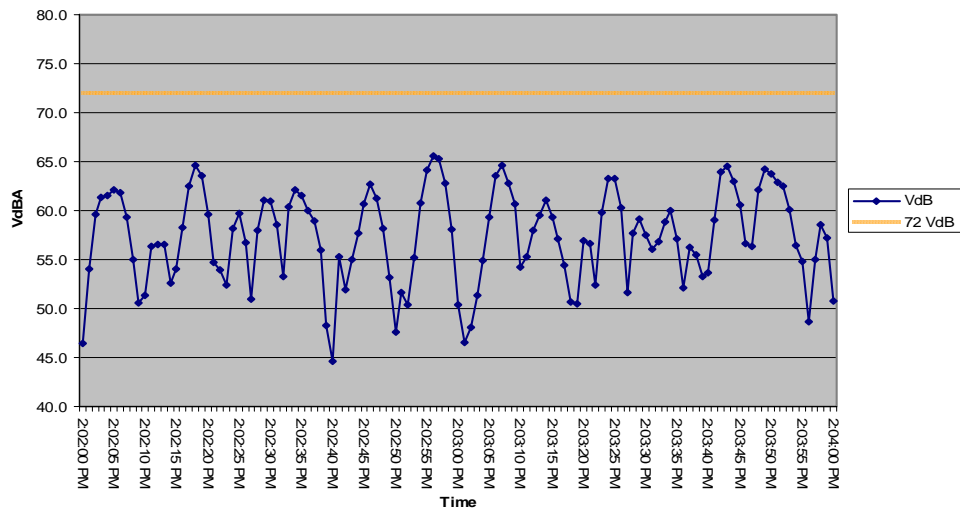
1:52 to 1:54 No Trains



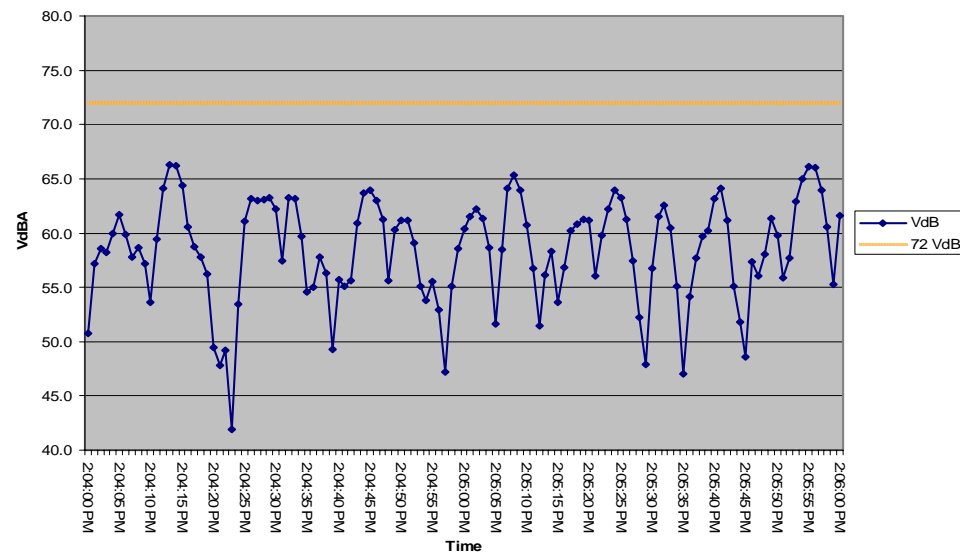
**2:01 Northbound Train Leaves Universal City
Arrives North Hollywood 2:03**



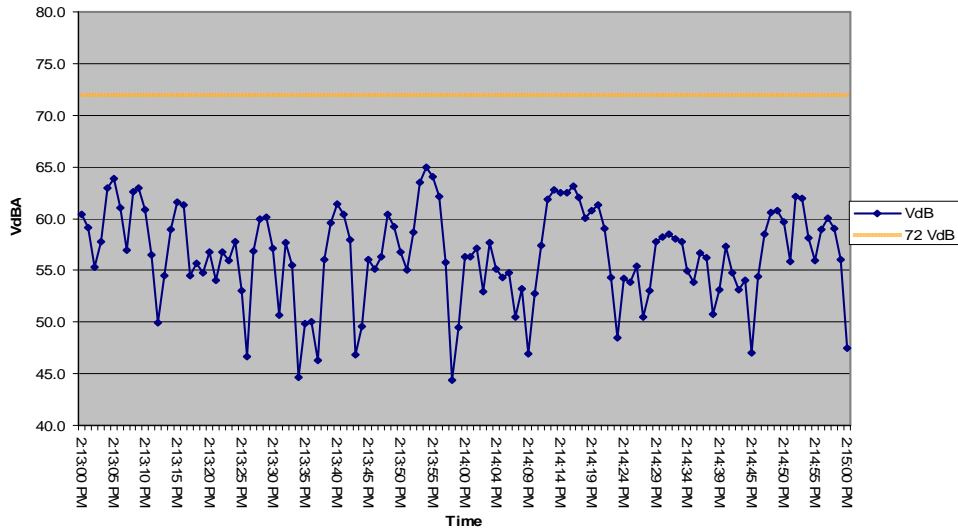
**2:02 Southbound Leaves North Hollywood
Arrives Universal City 2:04**



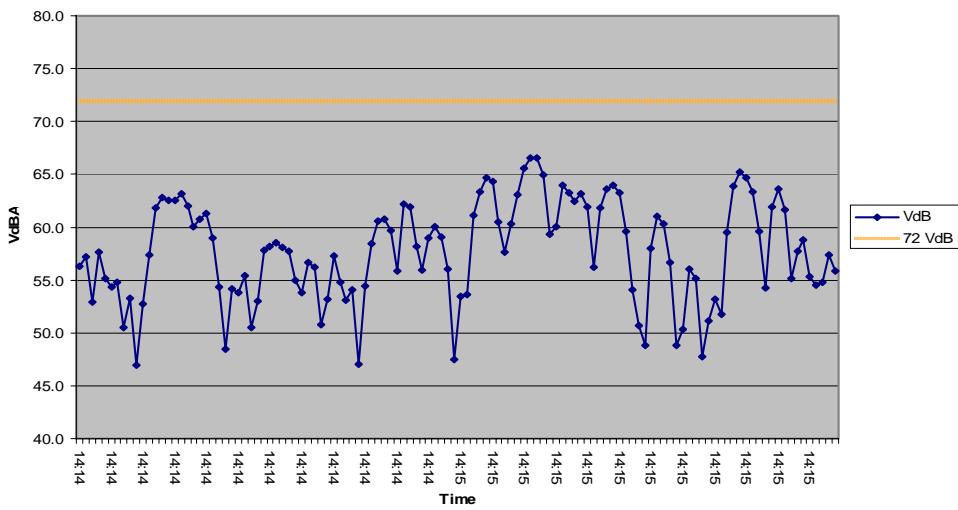
2:04 to 2:06 No Trains



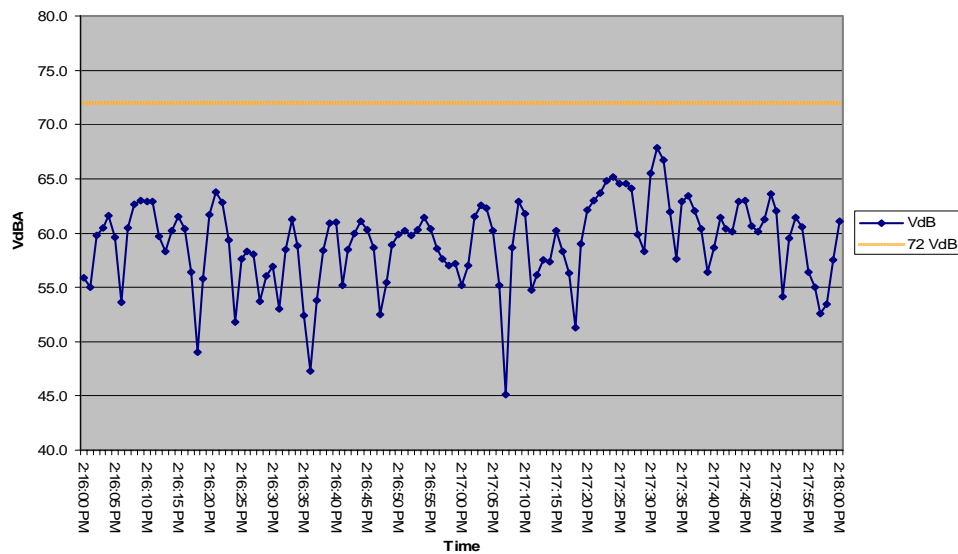
**2:13 Northbound Train Leaves Universal City
Arrives North Hollywood 2:15**



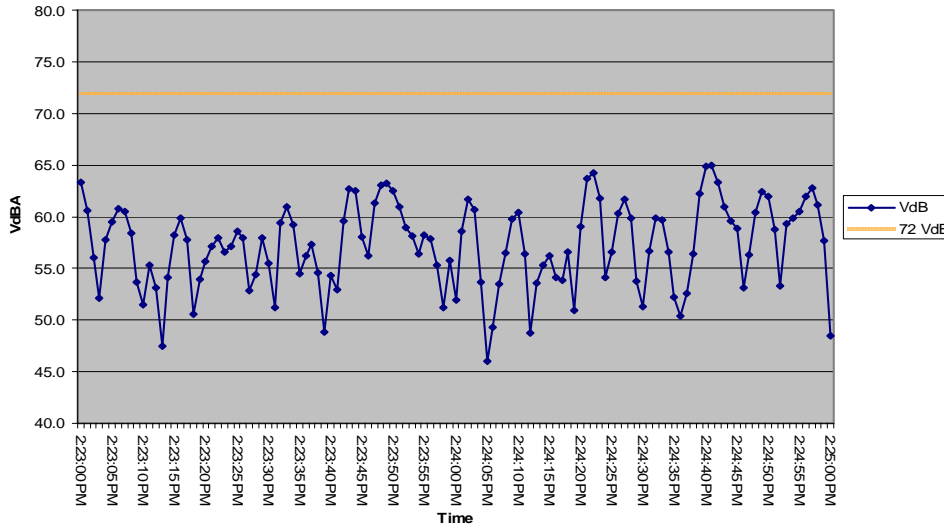
**2:14 Southbound Leaves North Hollywood
Arrives Universal City 2:16**



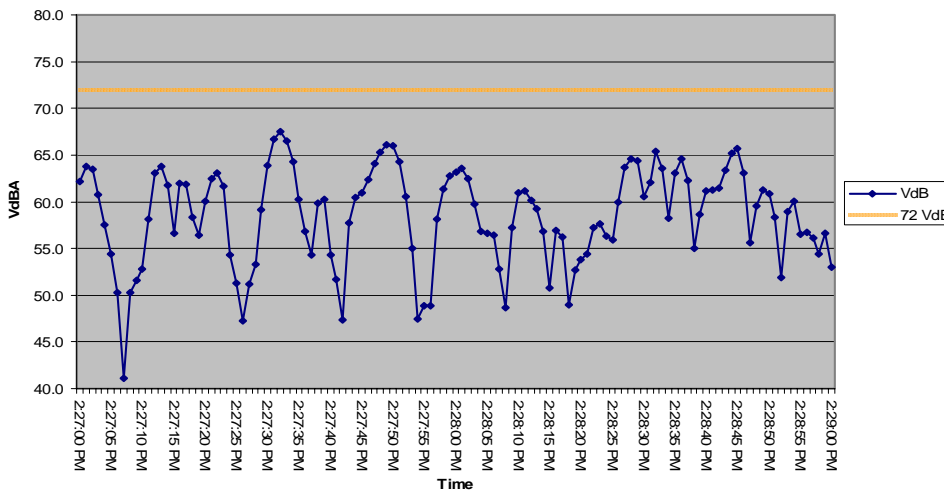
2:16 to 2:18 No Trains



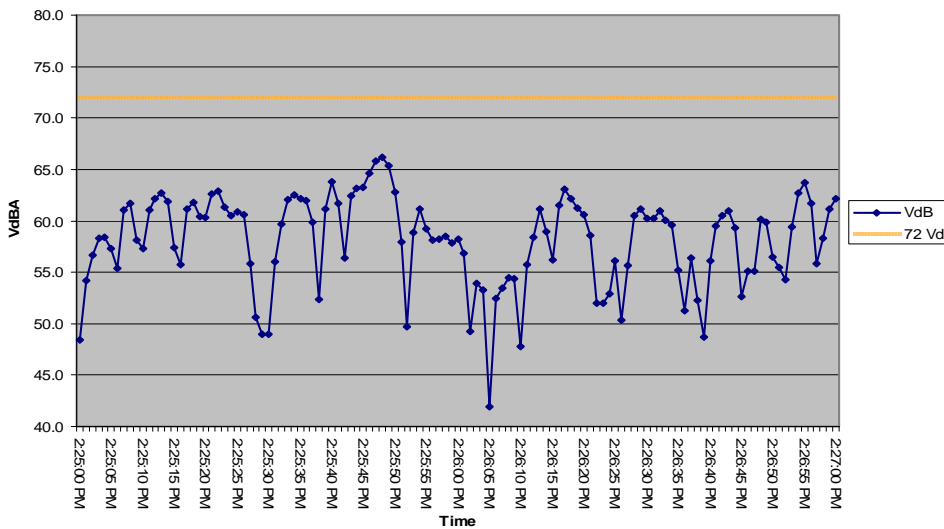
**2:23 Northbound Train Leaves Universal City
Arrives North Hollywood 2:25**



**2:27 Southbound Leaves North Hollywood
Arrives Universal City 2:29**

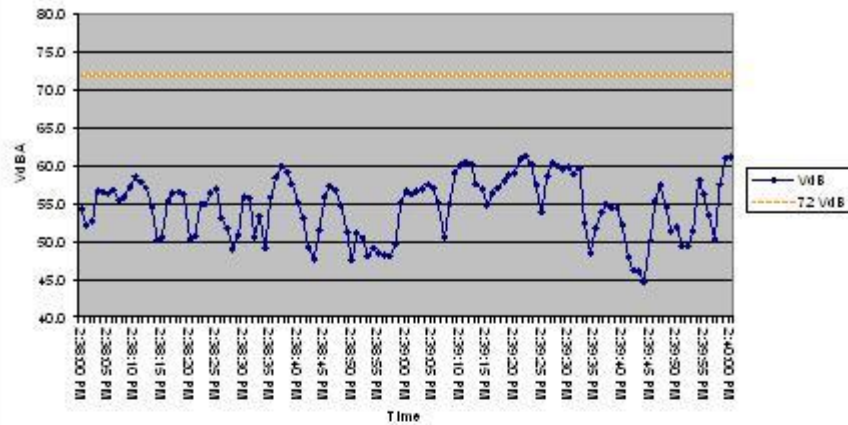


2:25 to 2:27 No Trains

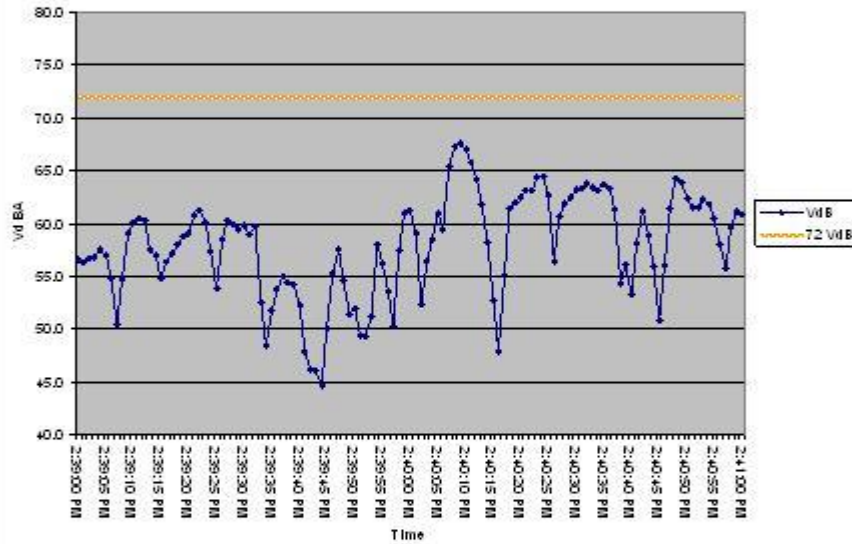


Site V-3 3075 Wilshire Boulevard

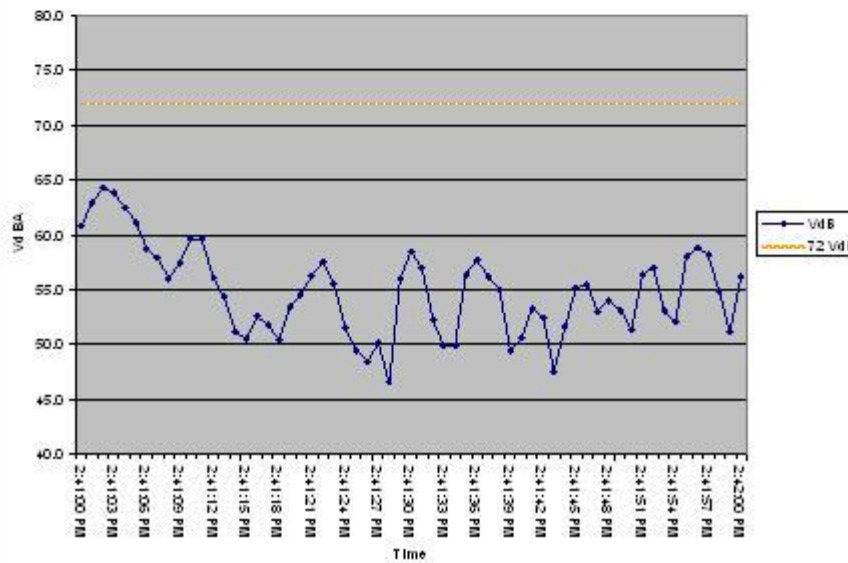
2:38 Southbound Train Leaves Wiltshire/Vermont
Arrives V&E/Blake/MacArthur Park 2:40

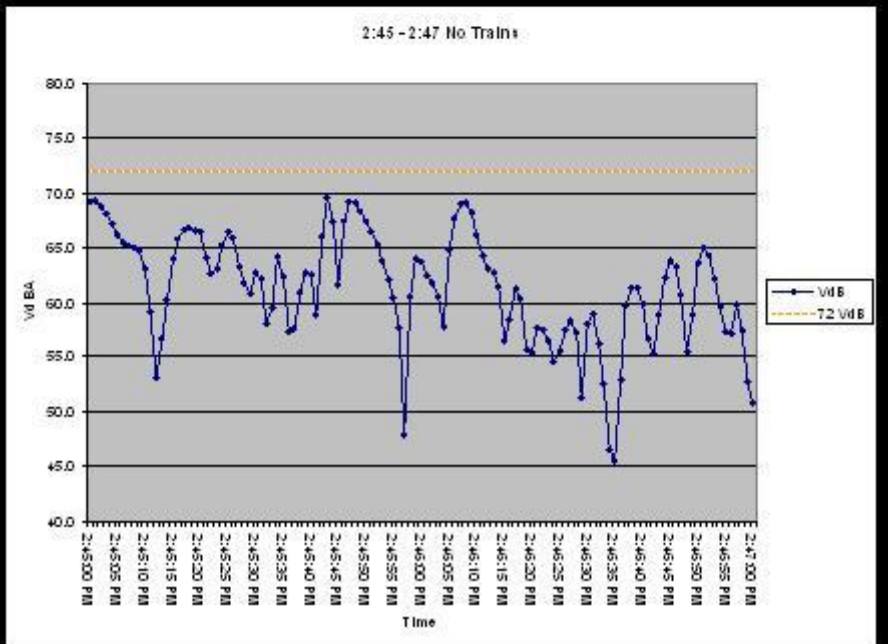
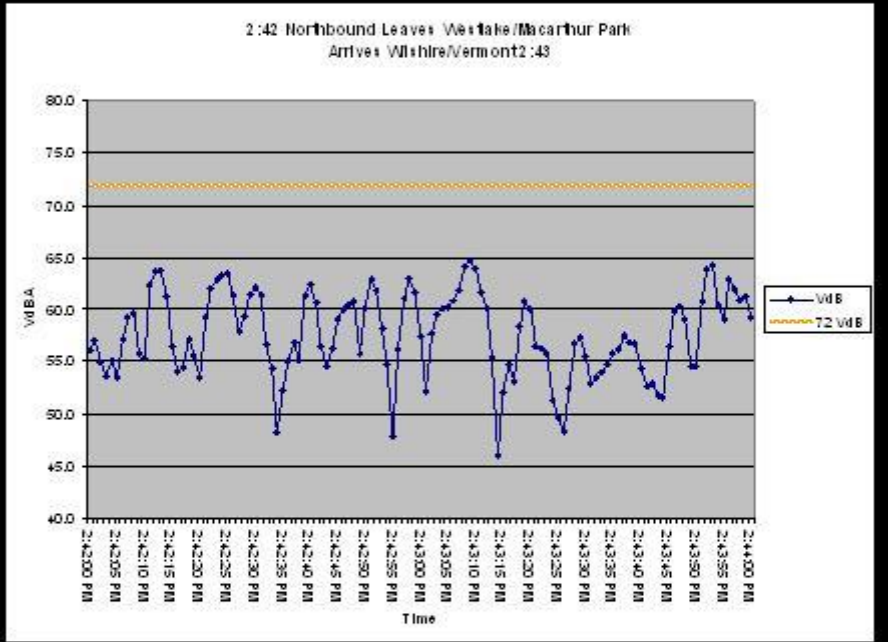
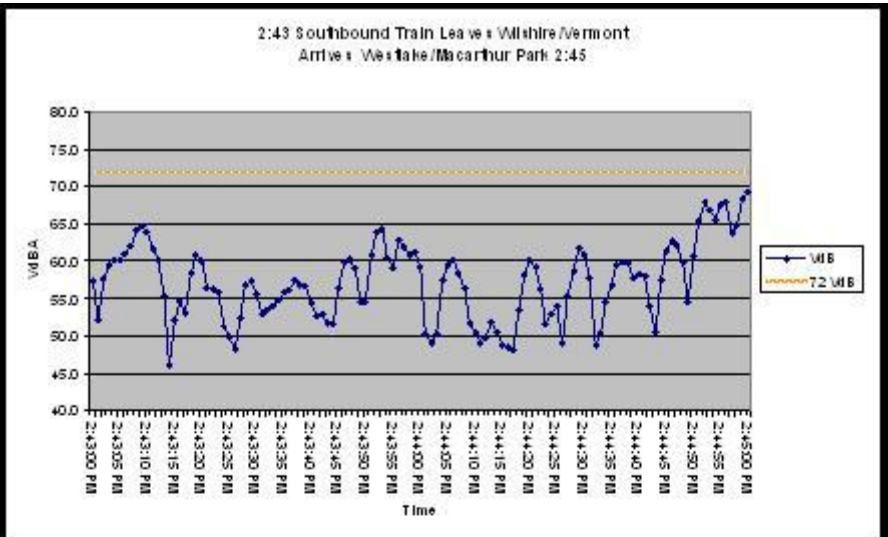


2:39 Northbound Leaves V&E/Blake/MacArthur Park
Arrives Wiltshire/Vermont 2:41

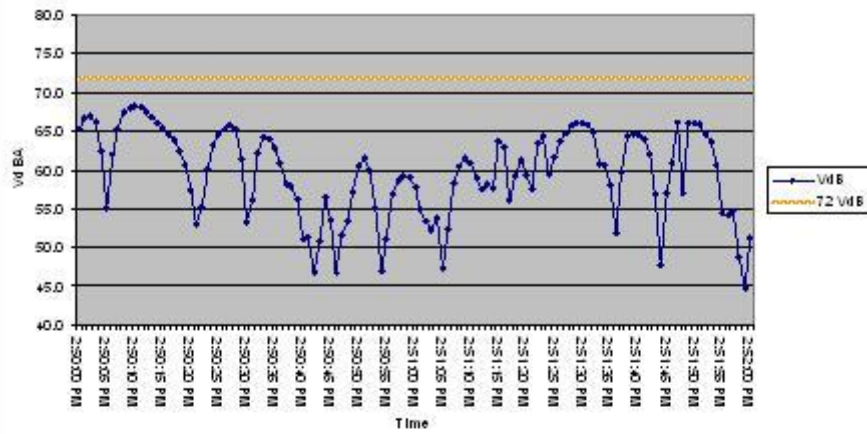


2:41 - 2:42 No Trains

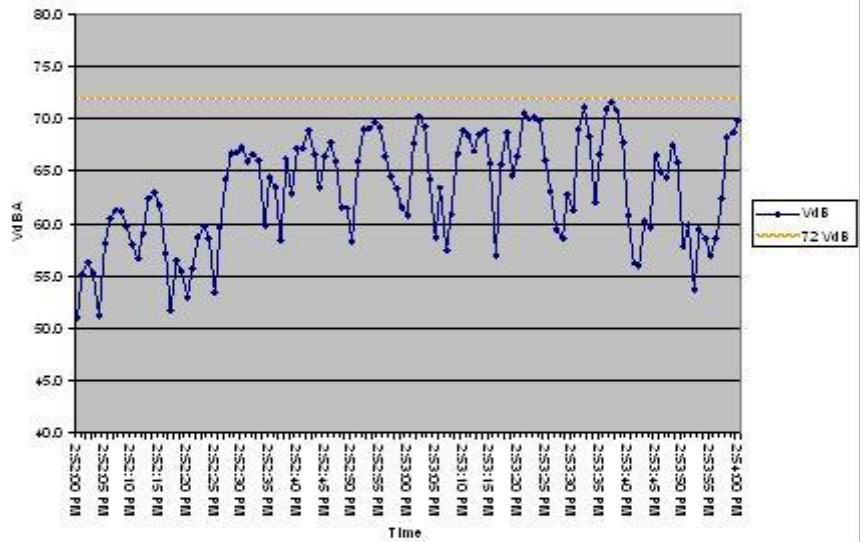




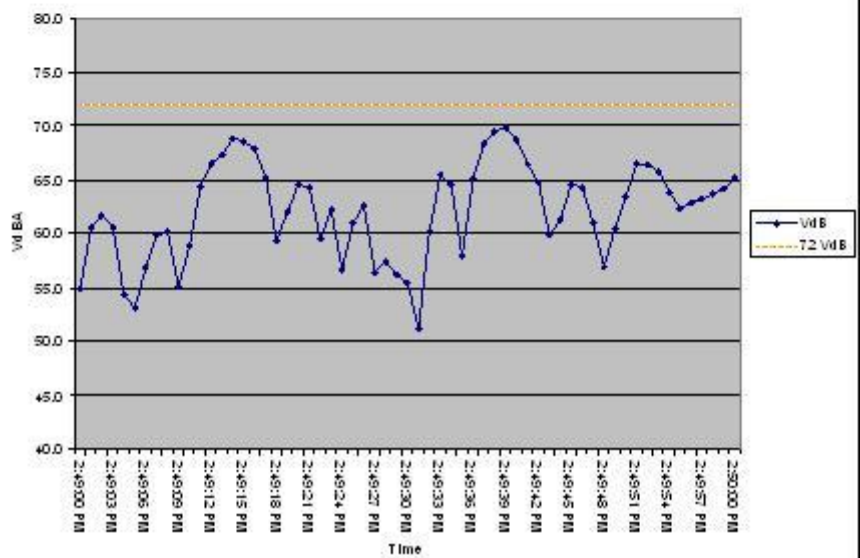
2:50 Southbound Train Leaves W/shire/Vermont
Arrives W/State/MacArthur Park 2:52



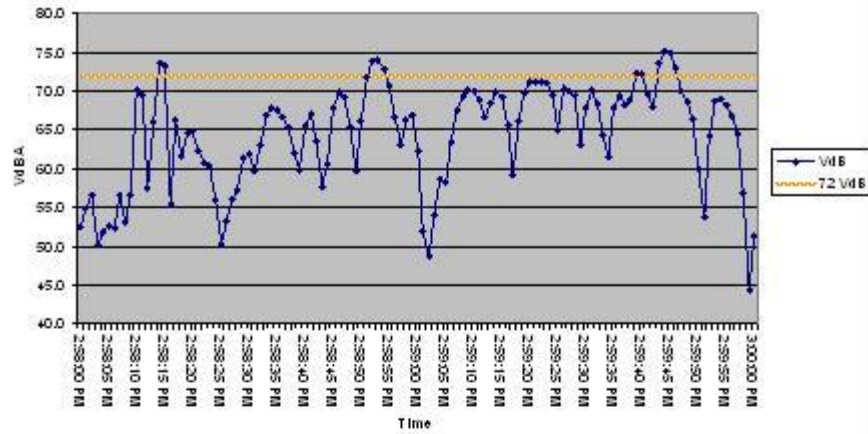
2:52 Northbound Leaves W/State/MacArthur Park
Arrives W/shire/Vermont 2:54



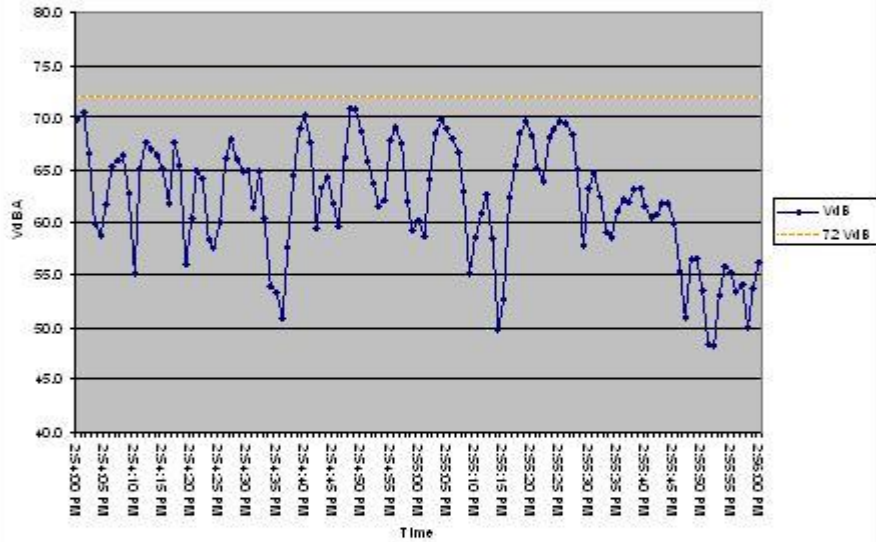
2:45 - 2:50 No Trains



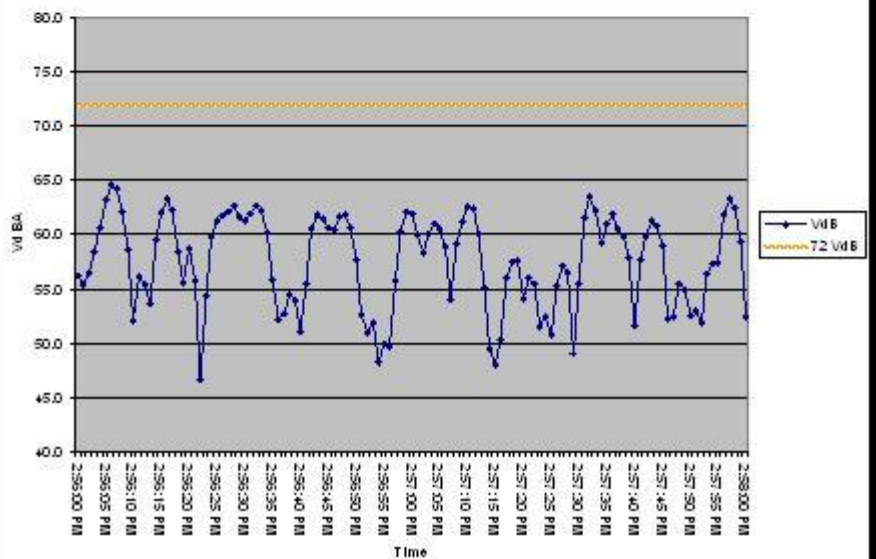
2:58 Southbound Train Leaves Wilshire/Vermont
Arrives Westlake/MacArthur Park 3:00



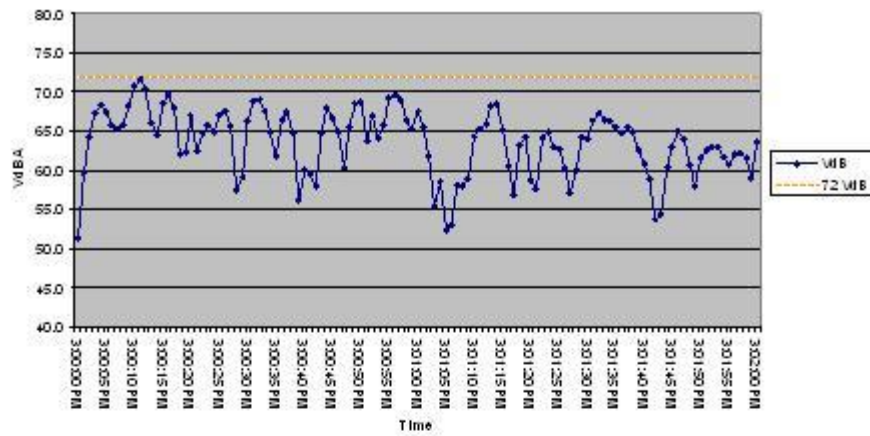
2:54 Northbound Leaves Westlake/MacArthur Park
Arrives Wilshire/Vermont 2:56



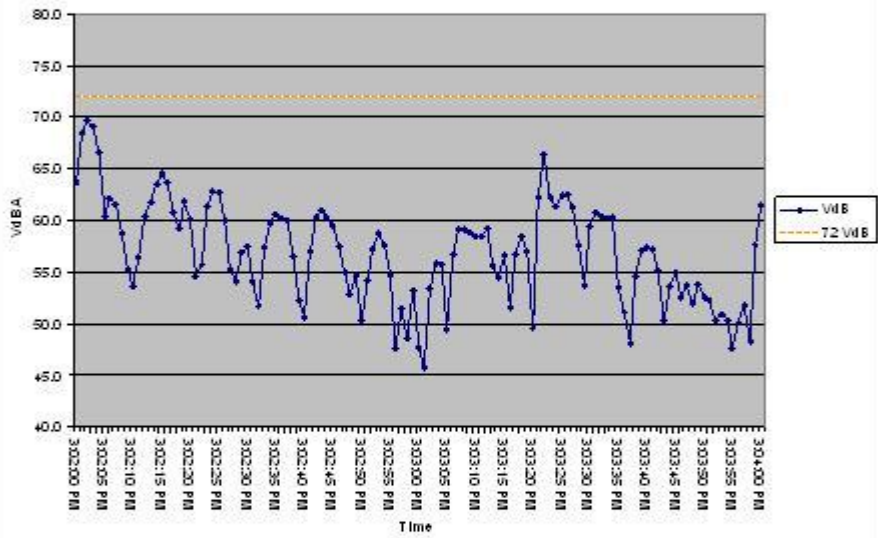
2:56 - 2:58 No Trains



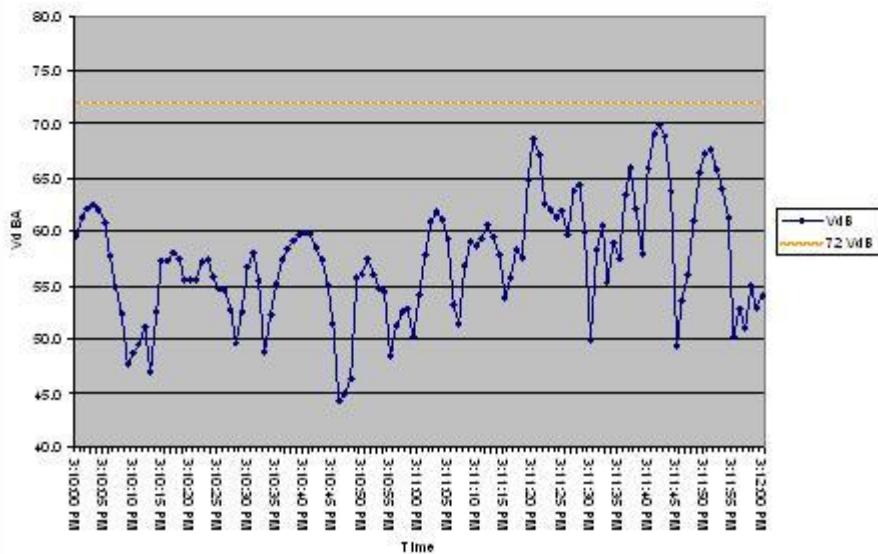
3:00 Southbound Train Leave Westlake/Vermont
Arrive Westlake/MacArthur Park 3:02



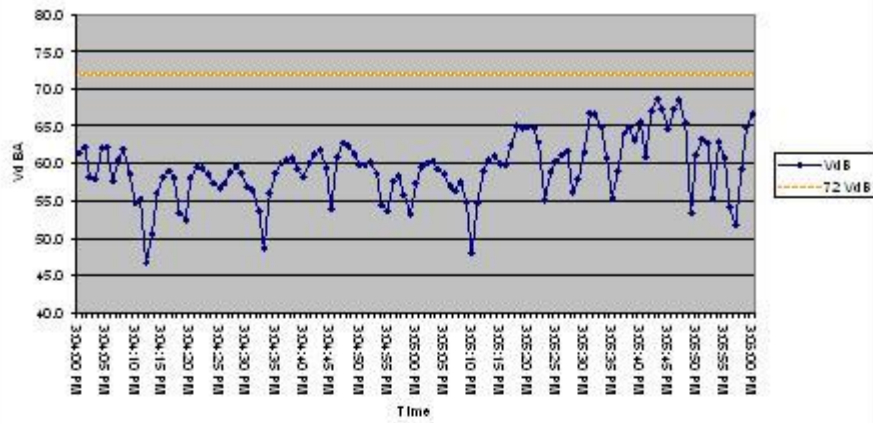
3:02 Northbound Leave Westlake/MacArthur Park
Arrive Westlake/Vermont 3:04



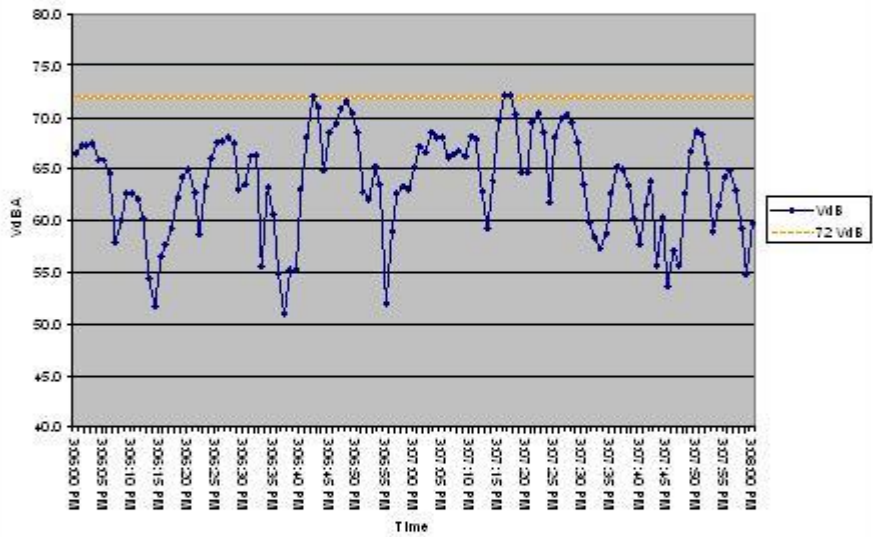
3:10 - 3:12 No Trains



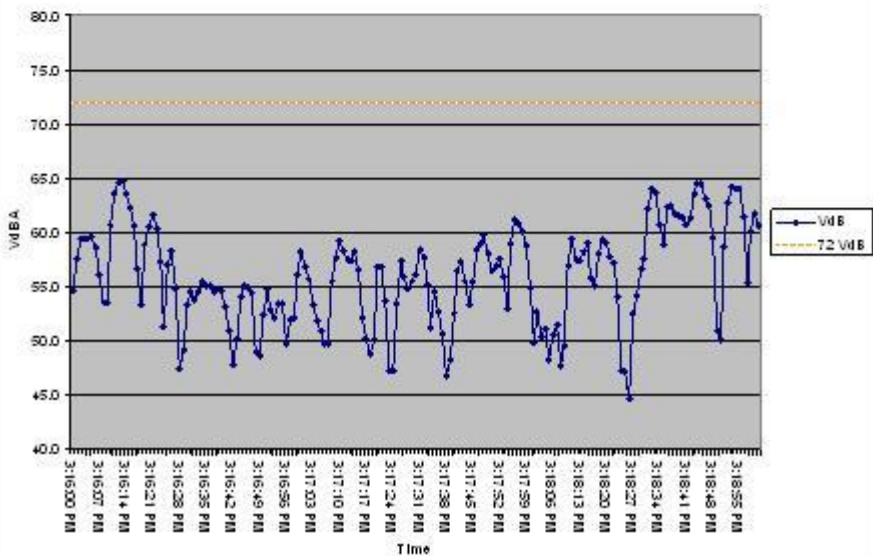
3:04 Southbound Train Leaves Wilshire/Vermont
Arrives Westlake/MacArthur Park 3:06



3:06 Northbound Leaves Westlake/MacArthur Park
Arrives Wilshire/Vermont 3:08

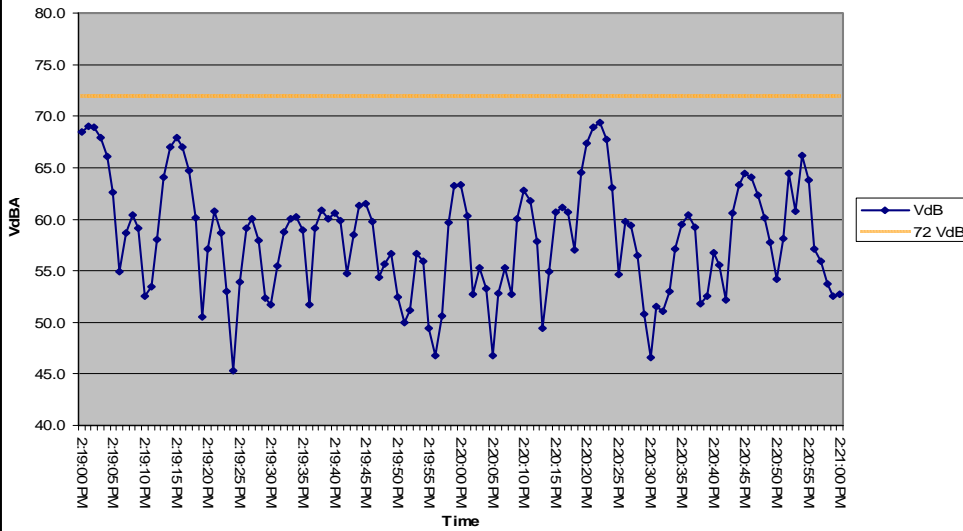


3:16 - 3:19 No Trains

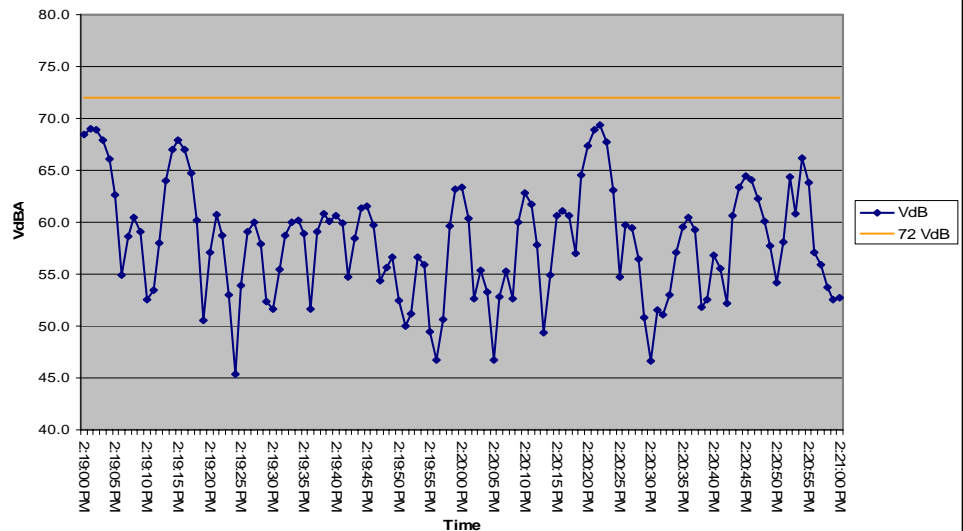


Site V-4 7200 Franklin Avenue

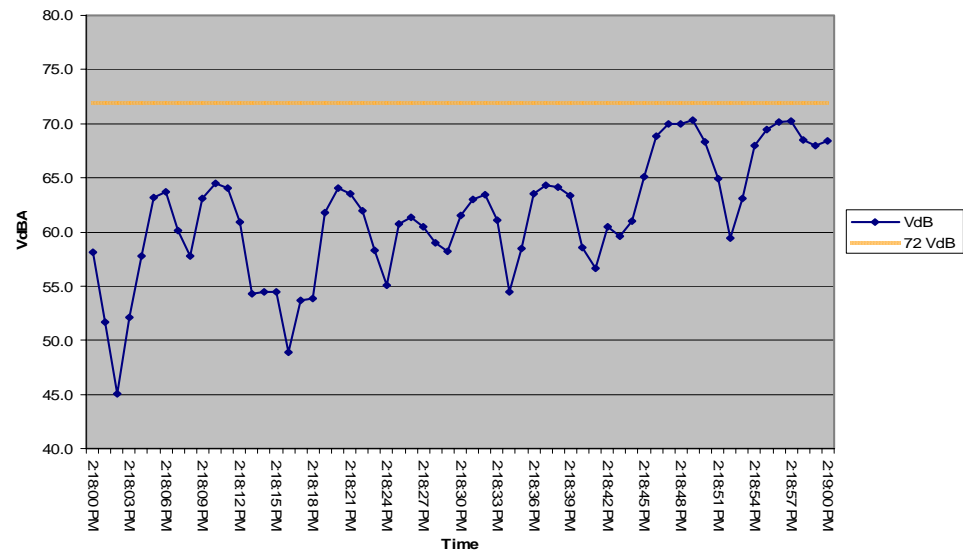
**2:19 Southbound Train Leaves Universal City
Arrives Hollywood/Highland 2:21**



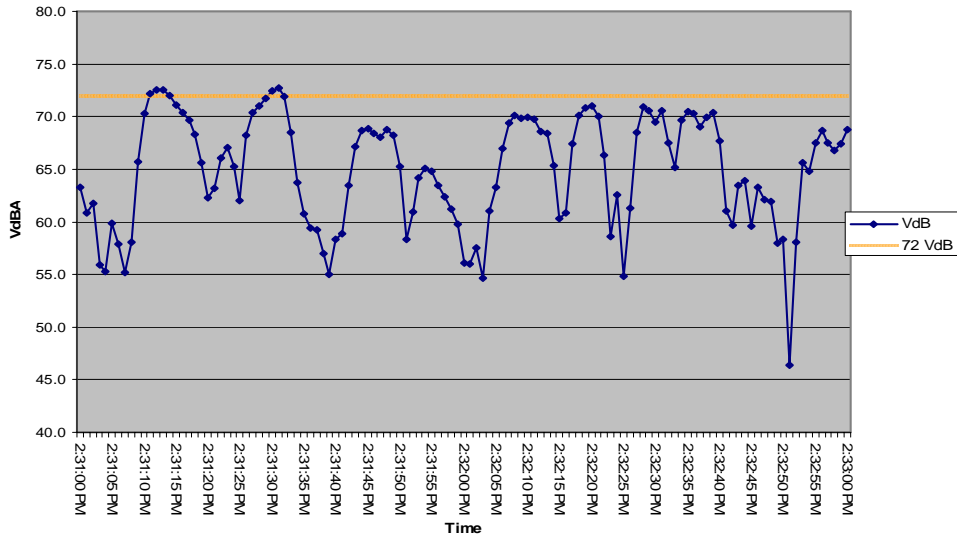
**2:19 Northbound Leaves Hollywood/Highland
Arrives Universal City 2:21**



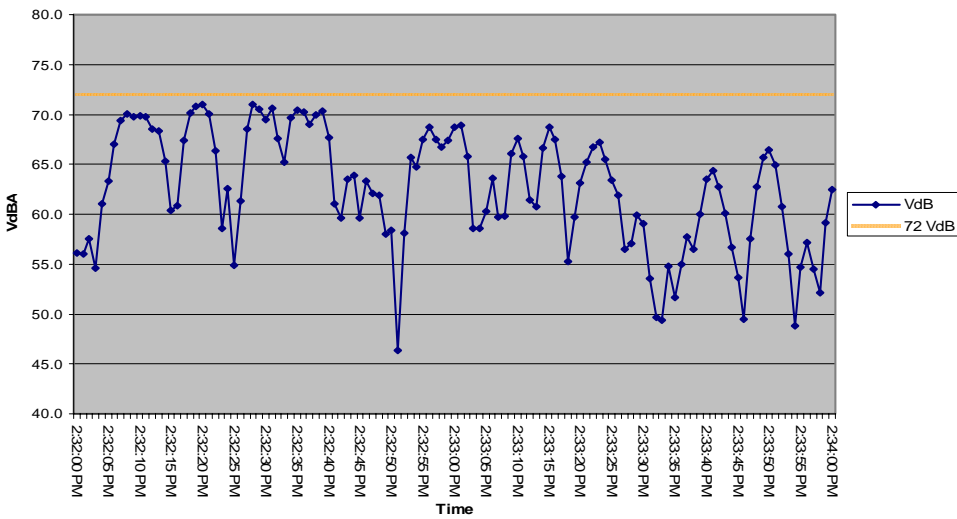
2:18 to 2:19 No Trains



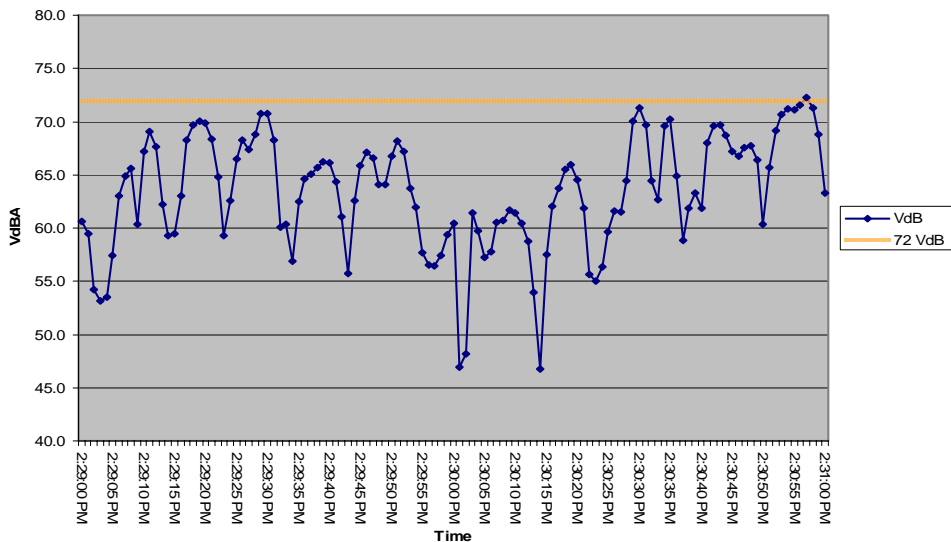
**2:31 Southbound Train Leaves Universal City
Arrives Hollywood/Highland 2:33**



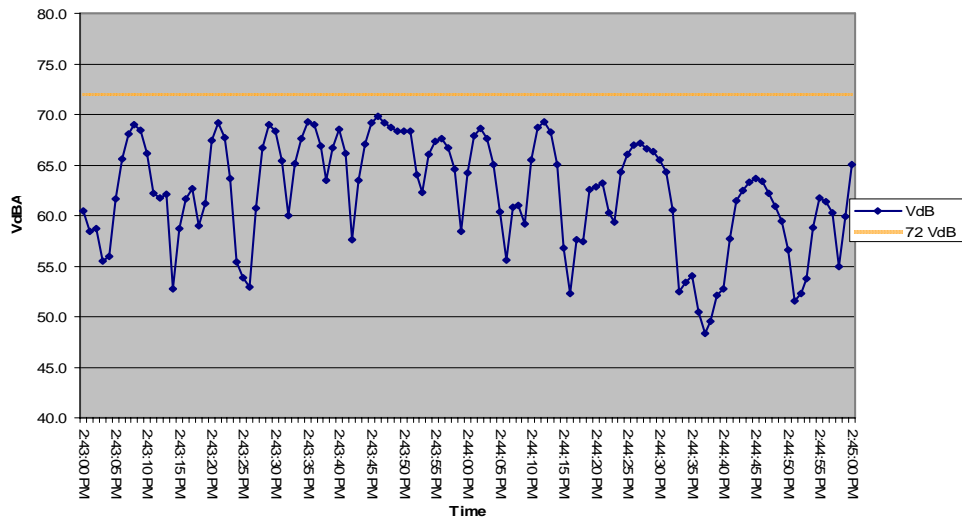
**2:32 Northbound Leaves Hollywood/Highland
Arrives Universal City 2:34**



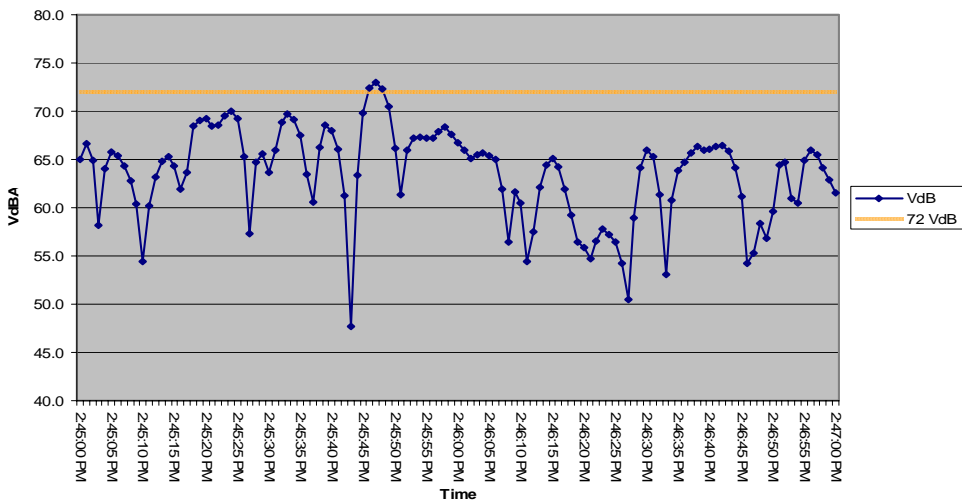
2:29 to 2:31 No Trains



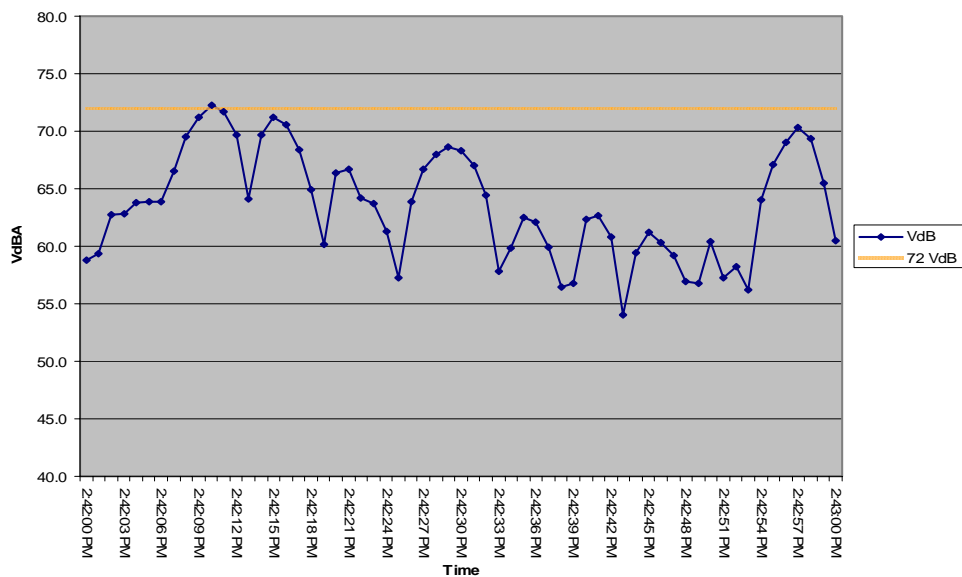
**2:43 Southbound Train Leaves Universal City
Arrives Hollywood/Highland 2:45**



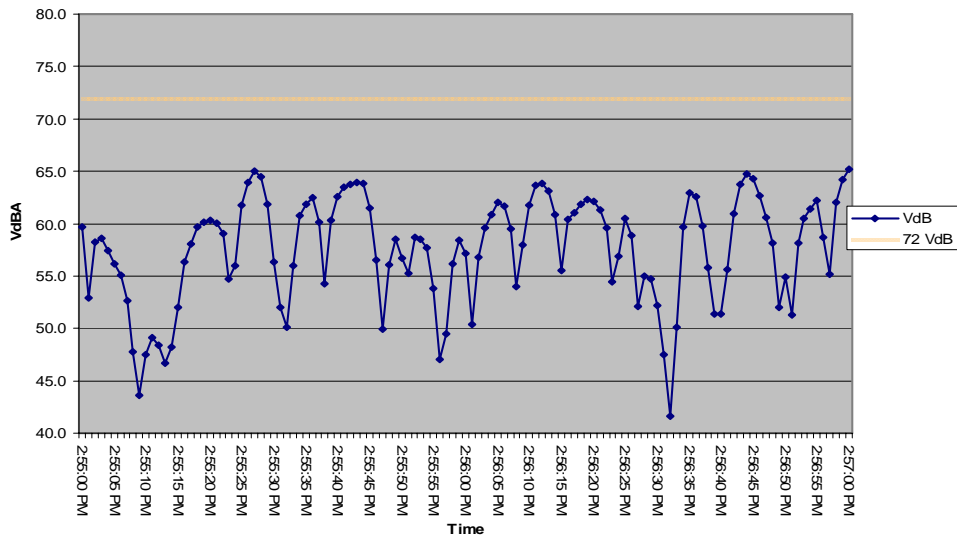
**2:45 Northbound Leaves Hollywood/Highland
Arrives Universal City 2:47**



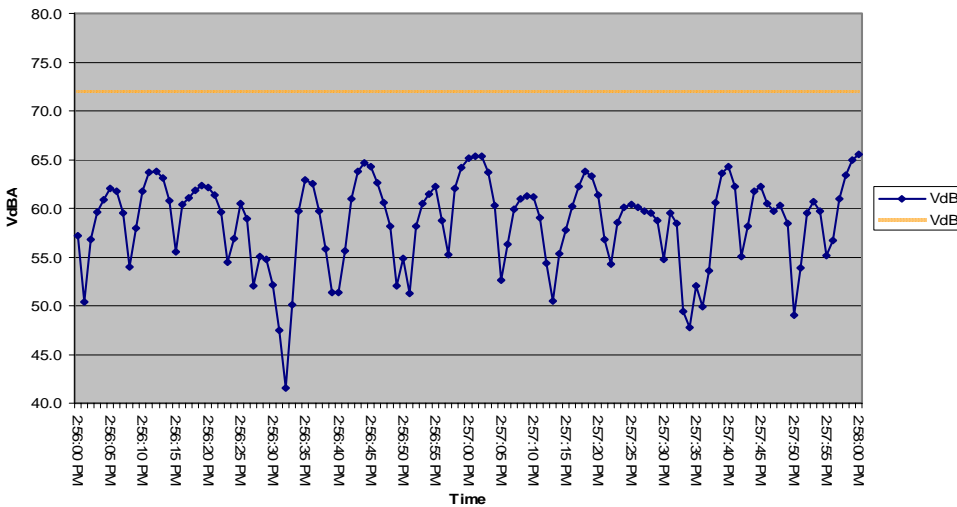
2:42 to 2:43 No Trains



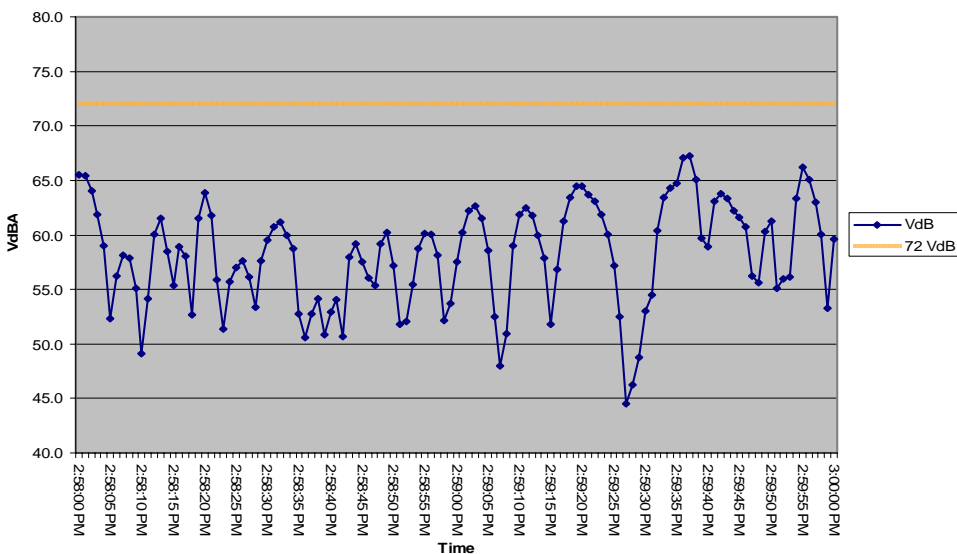
**2:55 Southbound Train Leaves Universal City
Arrives Hollywood/Highland 2:57**



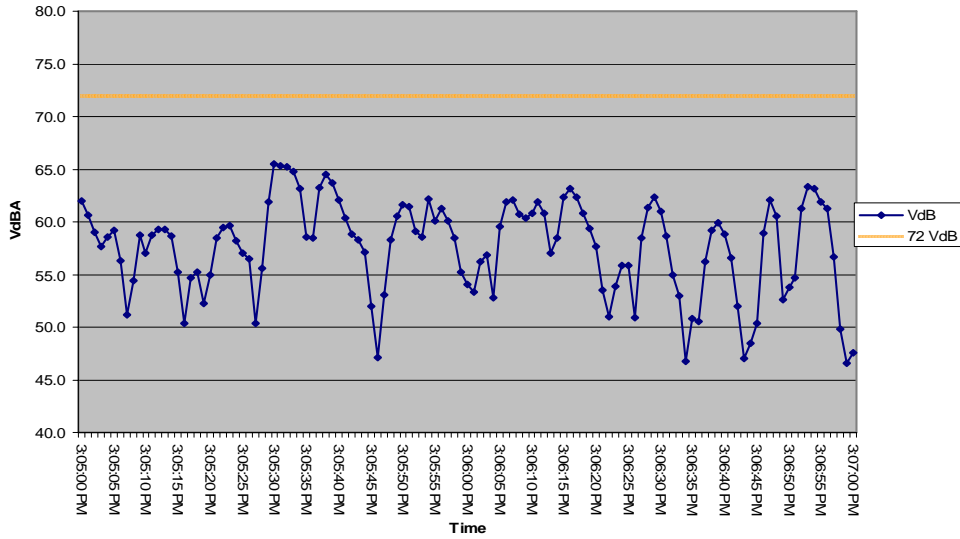
**2:56 Northbound Leaves Hollywood/Highland
Arrives Universal City 2:58**



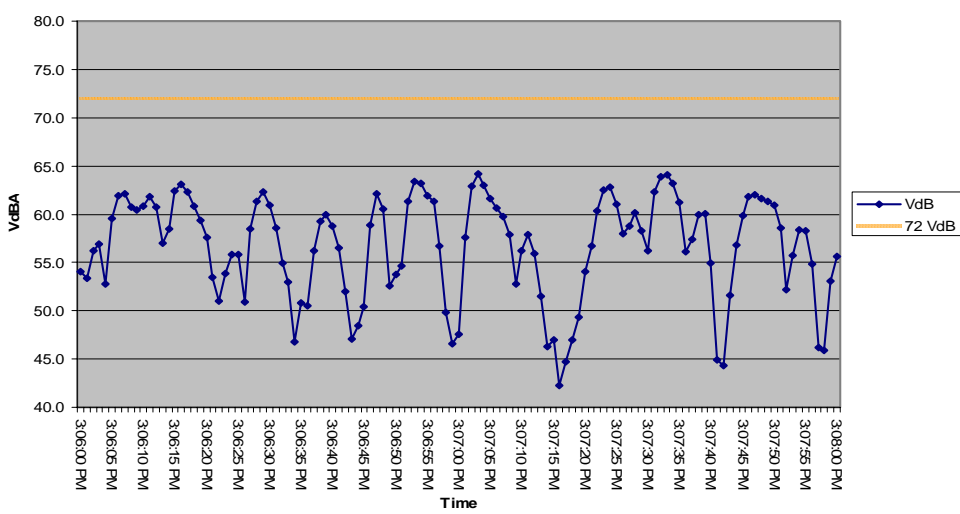
2:58 to 3:00 No Trains



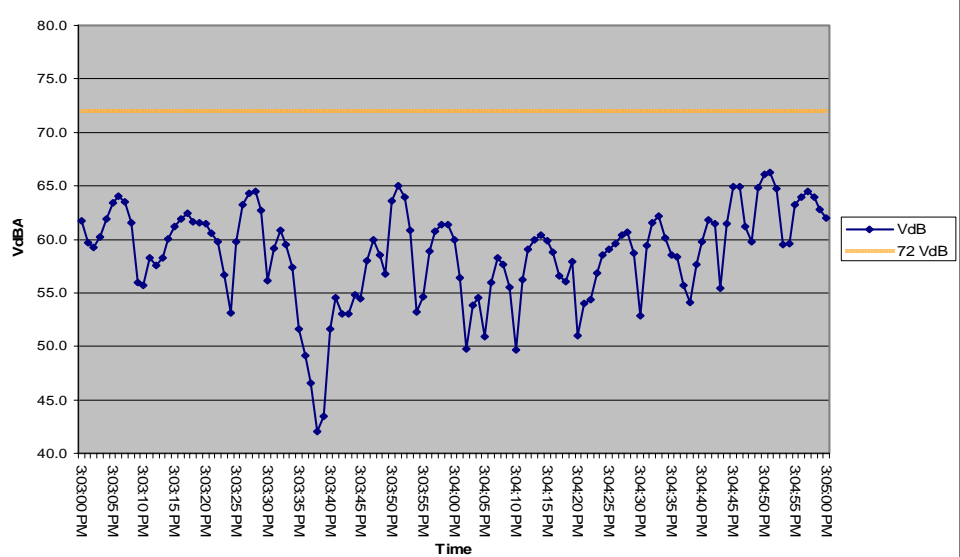
**3:05 Southbound Train Leaves Universal City
Arrives Hollywood/Highland 3:07**



**3:06 Northbound Leaves Hollywood/Highland
Arrives Universal City 3:08**

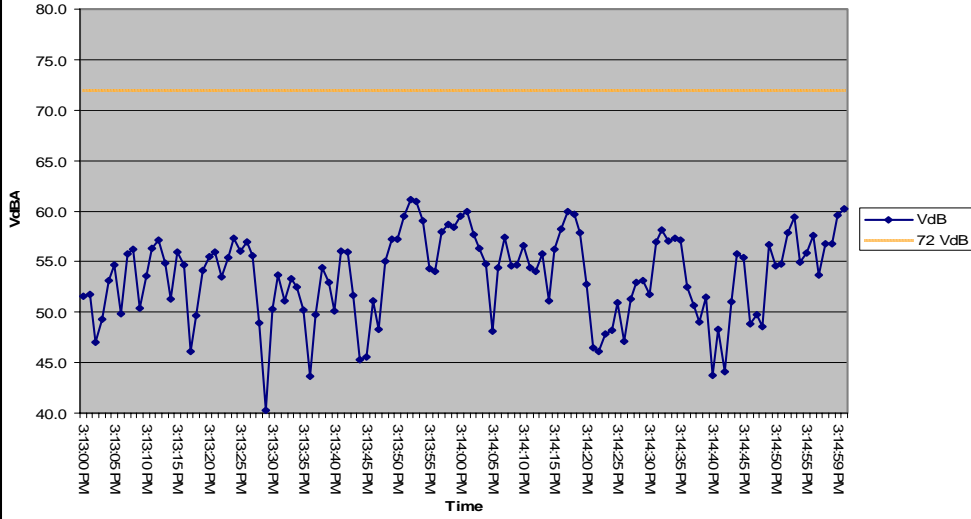


3:03 to 3:05 No Trains

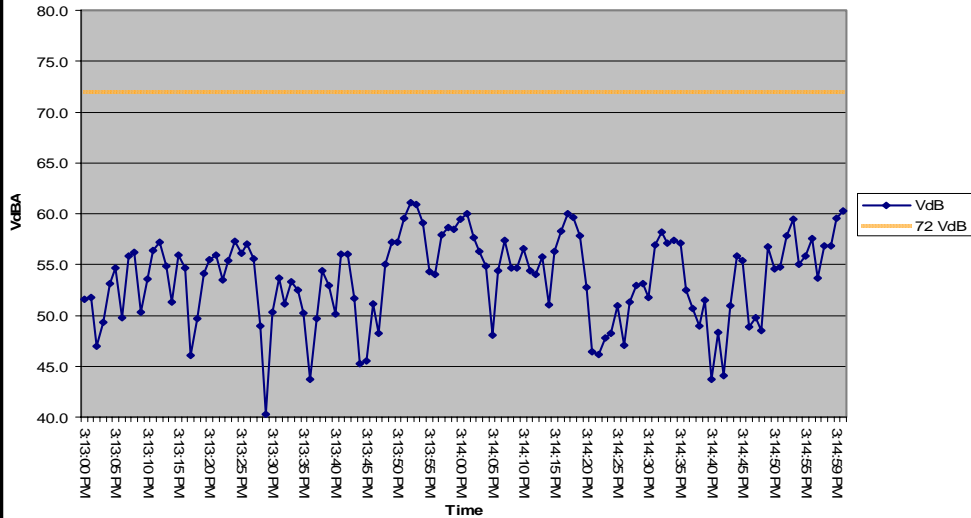


Site V-5 Macarthur Park @ Wilshire and Parkview

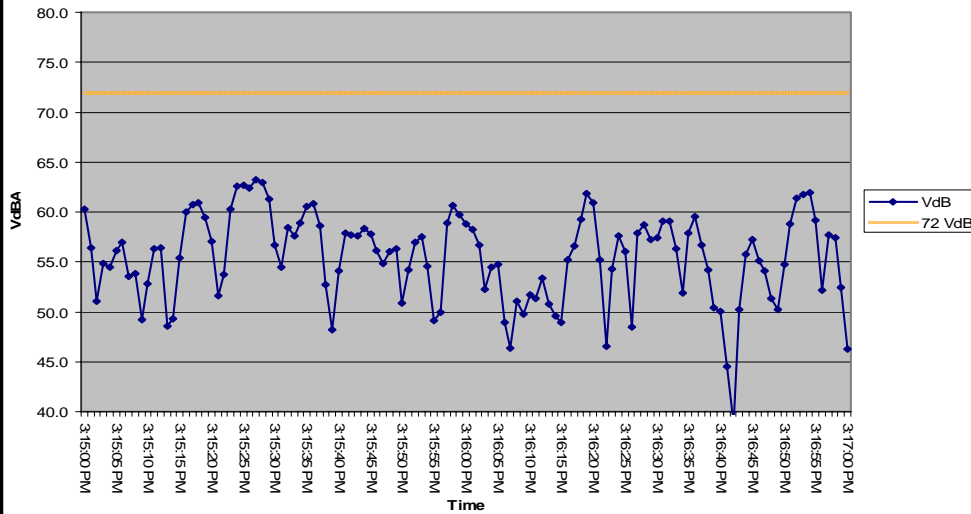
**3:13 Northbound Train Leaves Westlake
Arrives Wilshire/Vermont 3:15**



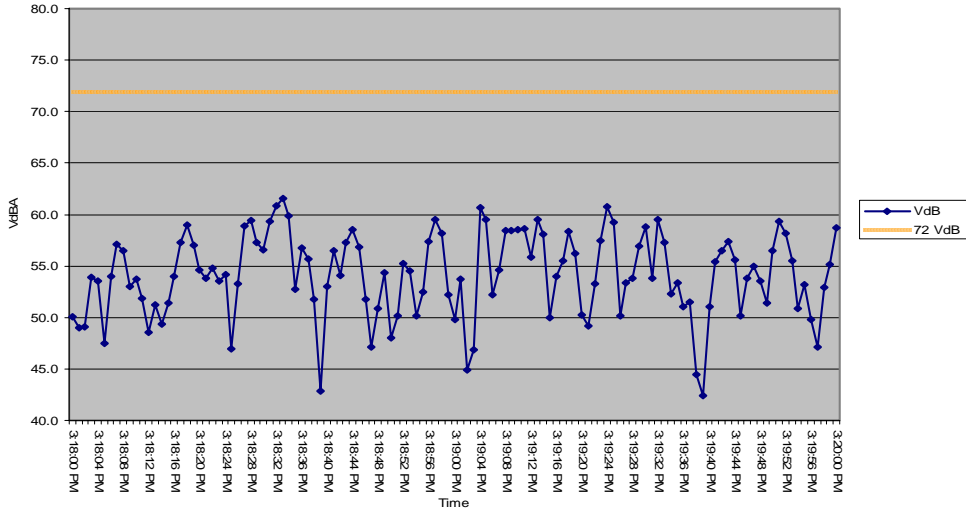
**3:13 Southbound Train Leaves Wilshire/Vermont
Arrives Westlake 3:15**



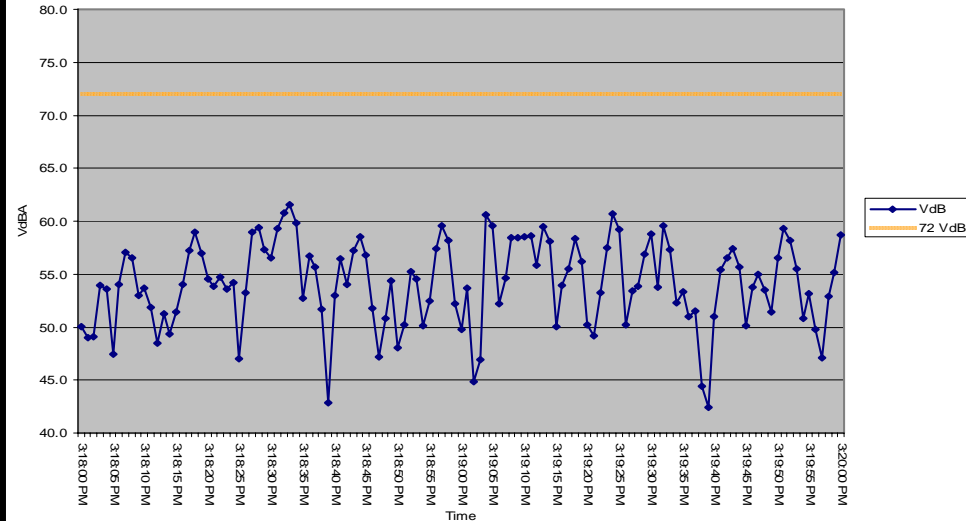
3:15 to 3:17 No Train



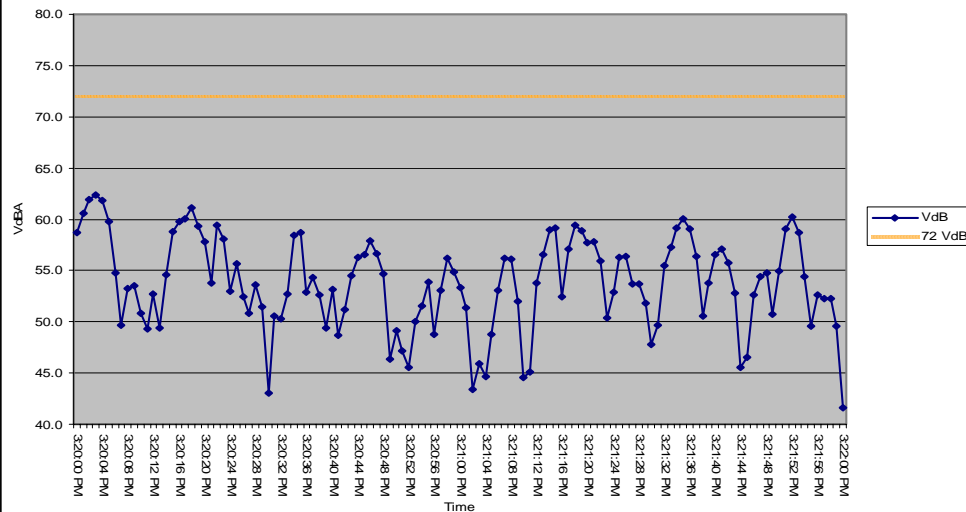
**3:18 Northbound Train Leaves Westlake
Arrives Wilshire/Vermont 3:20**



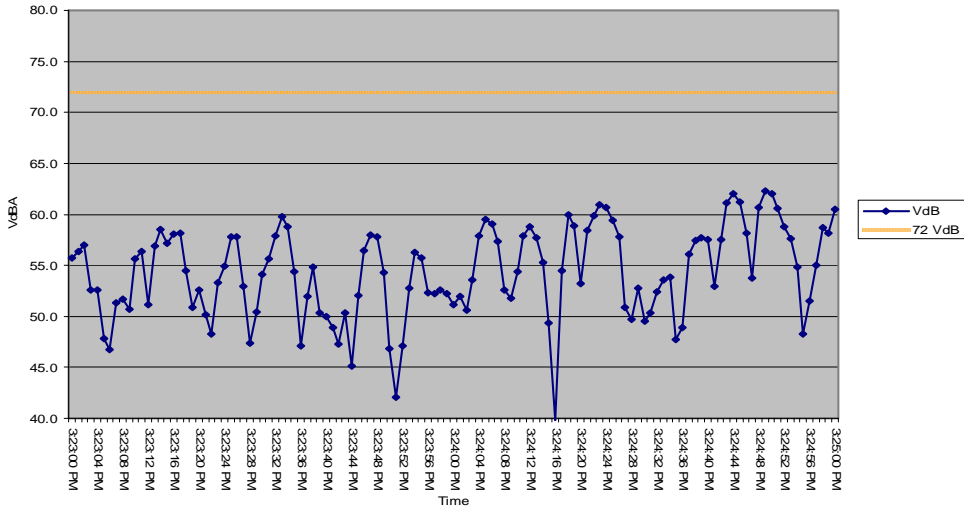
**3:18 Southbound Train Leaves Wilshire/Vermont
Arrives Westlake 3:20**



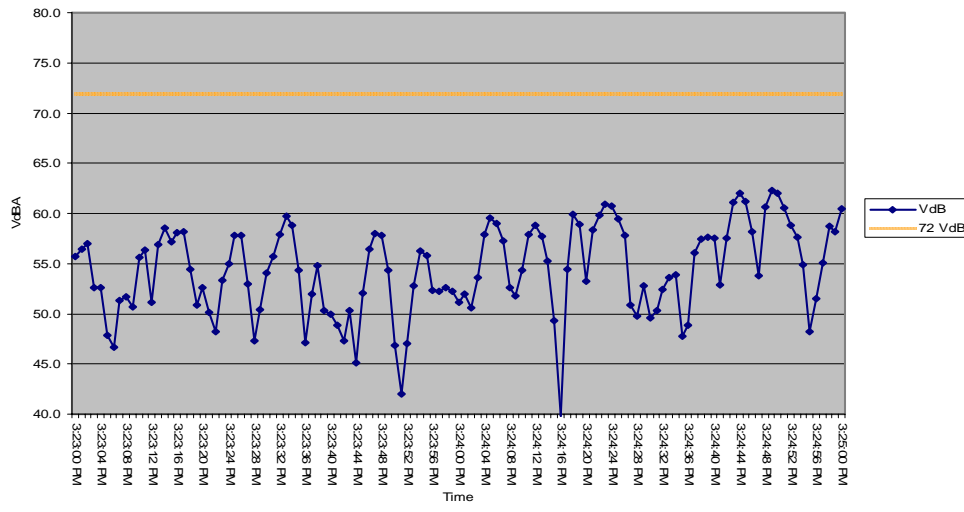
3:20 to 3:22 No Train



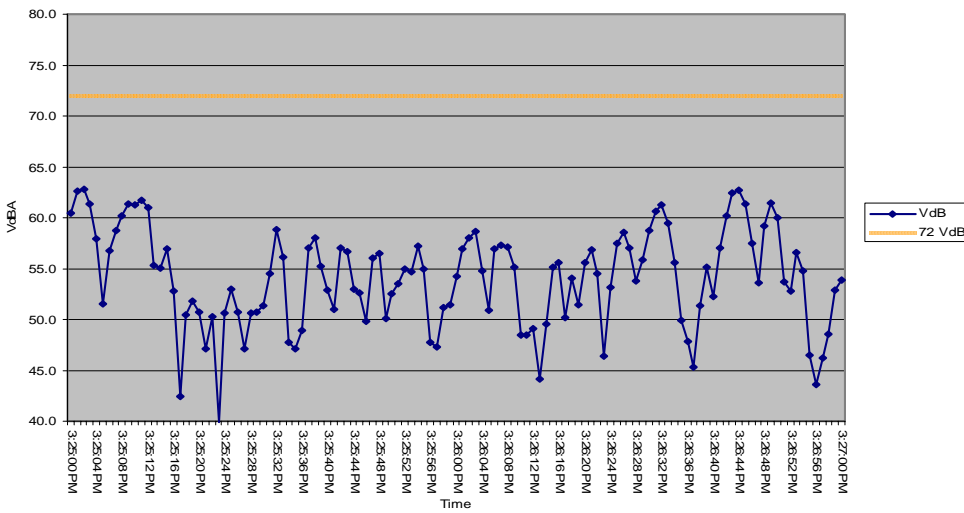
**3:23 Northbound Train Leaves Westlake
Arrives Wilshire/Vermont 3:25**



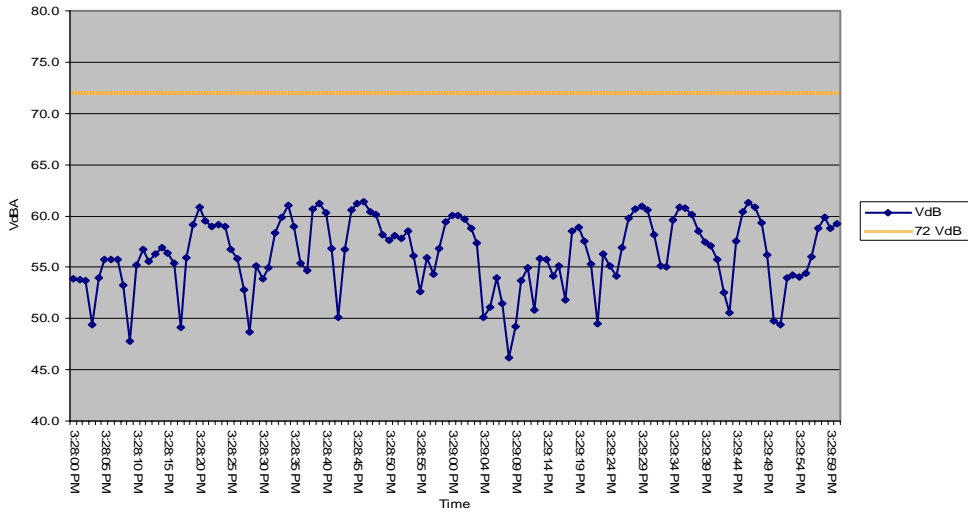
**3:23 Southbound Train Leaves Wilshire/Vermont
Arrives Westlake 3:25**



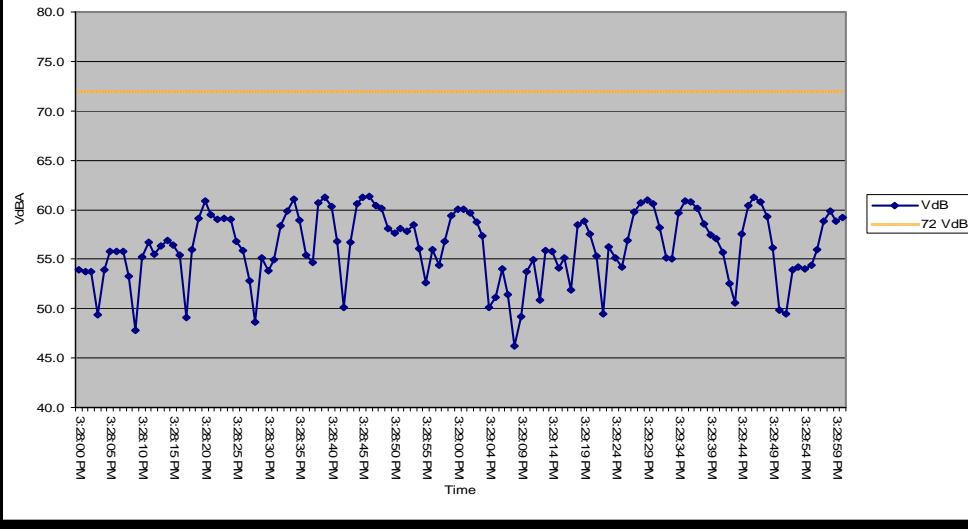
3:25 to 3:27 No Train



**3:28 Northbound Train Leaves Westlake
Arrives Wilshire/Vermont 3:30**



**3:28 Southbound Train Leaves Wilshire/Vermont
Arrives Westlake 3:30**



3:30 to 3:32 No Train

