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Continued Noise and Smoothness Monitoring on Concrete Pilot Projects of Grind and Groove and Continuously Reinforced Concrete Pavements

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Continued Noise and Smoothness Monitoring on Concrete Pilot Projects of Grind and Groove on Existing Pavement and Current Texture Types on Continuously Reinforced Concrete Pavements

Authors:
Irwin Guada and John Harvey

Partnered Pavement Research Center (PPRC) Strategic Plan Element Number 3.35: Quieter Pavement Monitoring
(DRISI Task 2710)

PREPARED FOR:
California Department of Transportation
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PREPARED BY:
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The goal of this project, titled "Quieter Pavement Monitoring," is to continue measuring noise and smoothness on previous concrete pavement surfacing techniques and the new grind and groove (GnG) surface, and on continuously reinforced concrete pavement (CRCP). Previous studies have initiated the investigation into both the noise properties of GnG and CRCP. This project gathered data in 2016 and early 2017 on the performance of these concrete pavements in terms of noise and smoothness. These data will be added to the noise database to further the development of specifications, guidelines, and standardized field test methods toward quieter pavements. The GnG technology on test sections in Caltrans pilot projects was evaluated in terms of measured tire/pavement noise, smoothness, friction, and surface drainability. The results of this study are to be used to further incorporate quieter pavement research into standard Caltrans practice and may serve as a basis for changes in quieter pavement policy and specifications. This report presents the results of testing completed in 2016 and 2017 on sections first tested in 2012 and 2013. Recommendations include continued monitoring of GnG, considering use on CRCP, and continued use of diamond grinding. Additional testing will be performed between 2017 and 2020.</td></tr>
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- Ongel, A., Harvey, J.T., Kohler, E, Lu, Q., and Steven, B.D. 2008. *Investigation of Noise, Durability, Permeability, and Friction Performance Trends for Asphaltic Pavement Surface Types: First- and Second-Year Results* (UCPRC-RR-2007-03). Davis and Berkeley, CA: University of California Pavement Research Center.
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LIST OF ABBREVIATIONS

AADT	Average annual daily traffic
AASHTO	American Association of State Highway and Transportation Officials
ASTM	American Society for Testing and Materials
Caltrans	California Department of Transportation
CDG	Conventional diamond grinding
CRCP	Continuously reinforced concrete pavement
EB	Eastbound
GnG	Grind and groove
IRI	International Roughness Index
JPCP	Joint plain concrete pavement
LT	Longitudinal tining
NB	Northbound
OBSI	On-Board Sound Intensity
PCC	Portland cement concrete
PM	Post mile
SB	Southbound
SRTT	Standard reference test tires
Std. Dev.	Standard deviation
UCPRC	University of California Pavement Research Center
WB	Westbound

SPECIFICATIONS USED IN THE REPORT

AASHTO TP 76	Standard Method of Test for Measurement of Tire/Pavement Noise Using the On-Board Sound Intensity (OBSI) Method. American Association of State Highway and Transportation Officials, 2009.
ASTM E950	Standard Test Method for Measuring the Longitudinal Profiles of Traveled Surfaces with an Accelerometer Established Inertial Profiling Reference. American Society for Testing and Materials, 2010.
ASTM E1926	Standard Practice for Computing International Roughness Index of Roads from Longitudinal Profile Measurements. American Society for Testing and Materials, 2010.

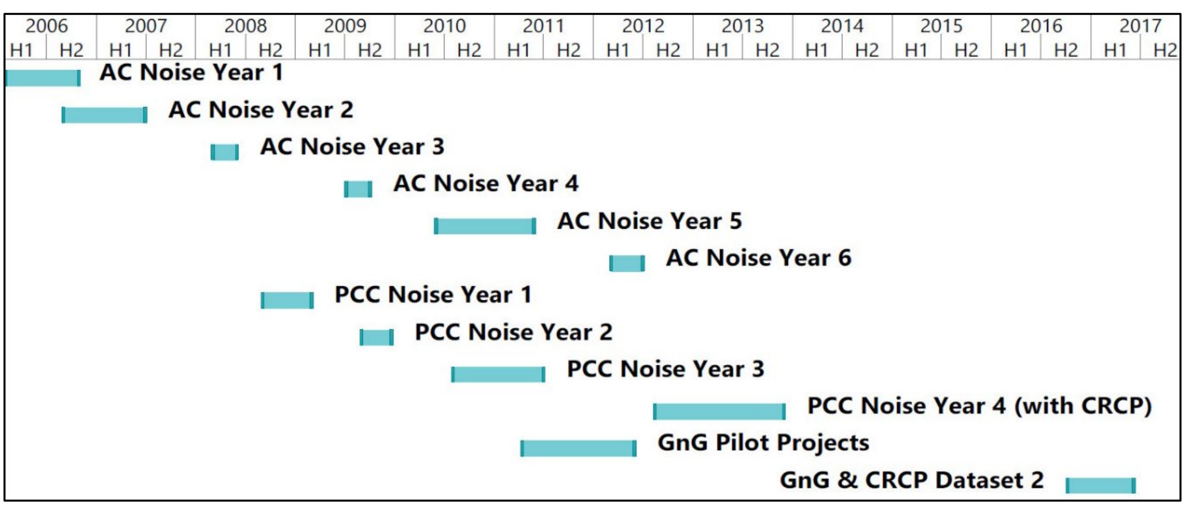
SI* (MODERN METRIC) CONVERSION FACTORS				
APPROXIMATE CONVERSIONS TO SI UNITS				
Symbol	**When You Know**	**Multiply By**	**To Find**	**Symbol**
LENGTH				
in.	inches	25.40	millimeters	mm
ft.	feet	0.3048	meters	m
yd.	yards	0.9144	meters	m
mi.	miles	1.609	kilometers	km
AREA				
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.09290	square meters	m^2
yd^2	square yards	0.8361	square meters	m^2
ac.	acres	0.4047	hectares	ha
mi^2	square miles	2.590	square kilometers	km^2
VOLUME				
fl. oz.	fluid ounces	29.57	milliliters	mL
gal.	gallons	3.785	liters	L
ft^3	cubic feet	0.02832	cubic meters	m^3
yd^3	cubic yards	0.7646	cubic meters	m^3
MASS				
oz.	ounces	28.35	grams	g
lb.	pounds	0.4536	kilograms	kg
T	short tons (2000 pounds)	0.9072	metric tons	t
TEMPERATURE (exact degrees)				
°F	Fahrenheit	(F-32)/1.8	Celsius	°C
FORCE and PRESSURE or STRESS				
lbf	pound-force	4.448	newtons	N
lbf/in^2	pound-force per square inch	6.895	kilopascals	kPa
APPROXIMATE CONVERSIONS FROM SI UNITS				
Symbol	**When You Know**	**Multiply By**	**To Find**	**Symbol**
LENGTH				
mm	millimeters	0.03937	inches	in.
m	meters	3.281	feet	ft.
m	meters	1.094	yards	yd.
km	kilometers	0.6214	miles	mi.
AREA				
mm^2	square millimeters	0.001550	square inches	in^2
m^2	square meters	10.76	square feet	ft^2
m^2	square meters	1.196	square yards	yd^2
ha	hectares	2.471	acres	ac.
km^2	square kilometers	0.3861	square miles	mi^2
VOLUME				
mL	milliliters	0.03381	fluid ounces	fl. oz.
L	liters	0.2642	gallons	gal.
m^3	cubic meters	35.31	cubic feet	ft^3
m^3	cubic meters	1.308	cubic yards	yd^3
MASS				
g	grams	0.03527	ounces	oz.
kg	kilograms	2.205	pounds	lb.
t	metric tons	1.102	short tons (2000 pounds)	T
TEMPERATURE (exact degrees)				
°C	Celsius	1.8C + 32	Fahrenheit	°F
FORCE and PRESSURE or STRESS				
N	newtons	0.2248	pound-force	lbf
kPa	kilopascals	0.1450	pound-force per square inch	lbf/in^2

*SI is the abbreviation for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.
(Revised April 2021)

PROJECT OBJECTIVES

The goal of this project, Partnered Pavement Research Center Strategic Plan Element (PPRC SPE) 3.35, titled "Quieter Pavement Monitoring," is to continue measuring noise and smoothness of newer concrete pavement construction techniques. Previous studies have initiated the investigation into both the noise properties of continuously reinforced concrete pavements (CRCP) and the grind and groove (GnG) surfacing technology. This project aims to gather recent data on the performance of these concrete pavements in terms of noise and smoothness. The use of CRCP and GnG resurfacing technology is growing within the state, and this data will be added to the noise database to further the development of specifications, guidelines, and standardized field test methods toward quieter pavements. The goal of the study presented in this report, which is a part of PPRC SPE 3.35, is to evaluate the GnG technology used on test sections in Caltrans pilot projects in terms of noise, smoothness, friction, and surface drainability. The results of this study will be used to further incorporate quieter pavement research into standard Caltrans practice and may serve as a basis for changes in quieter pavement policy and specifications.

The timeline below shows the Quieter Pavement noise studies conducted by the UCPRC through this report. This report presents the results of testing completed in 2016 and 2017 on sections first tested in 2012 and 2013.



Timeline of UCPRC Quiet Pavement research.

1 INTRODUCTION

1.1 Overview

In the early 2000s, the California Department of Transportation (Caltrans) identified a need for research on the noise-related performance properties of pavement surface textures used on the state highway network. In 2006 and 2008, research projects were initiated to evaluate the tire/pavement noise characteristics of existing asphalt and the performance properties of concrete pavements (*1,2,3*). In the fourth and final year of data collection on jointed plain concrete pavement (JPCP) surface textures, a few continuously reinforced concrete pavements (CRCPs) were introduced to the dataset. CRCP is a type of concrete pavement that Caltrans has used with increasing frequency since the late 2000s.

In the early 2010s, Caltrans also began investigating a new concrete surfacing technique developed by the American Concrete Pavement Association, along with Purdue University, called the Next Generation Concrete Surface (NGCS) (*4*). Caltrans refers to the version of this concrete surface texture used in California as grind and groove (GnG). Seven pilot projects were constructed to study the surface characteristics of the GnG surface, often in comparison to conventional diamond grinding (CDG) (*5*).

Only one set of data was collected in the initial study for both the CRCP sections added to the final year of the concrete noise study and the GnG pilot projects. This document reports the second set of data collected on these sections in 2016, presented with the initial readings from approximately four years prior. After only three to five years of service, these early results provide a preliminary quantification of the medium-term effects of traffic and age on noise and smoothness characteristics resulting from the use of continually reinforced pavements and from the use of the GnG texturing technique. The GnG technique is compared with the more typically used CDG technique for retexturing the surfaces of existing concrete pavements.

1.2 Problem Statement

Over the past few decades, awareness of the impacts of highway traffic noise has grown with increases in the number of vehicles and the populations either living close to highway corridors or conducting activities near them. In response, many departments of transportation have recognized the need to better understand the surface characteristics of pavements—not only because of the effect of pavement surface friction on safety and ride quality, but also because pavement surface characteristics contribute to noise generation through interaction with the vehicle's tires.

Vehicles contribute to highway noise from three sources: (1) mechanical, (2) exhaust, and (3) tire/pavement interaction. Tire/pavement interaction is the dominant source of noise at speeds above 30 mph for cars and 50 mph for trucks (*6*). In addition to sound barriers, highway agencies have focused on tire/pavement noise because they can manage it through selection and maintenance of pavement surfaces.

1.3 Structure of This Report

This report is organized as follows:

- Chapter 2 describes the test methods and test sections used in the study.
- Chapter 3 summarizes the test results collected on the evaluation sections.
- Chapter 4 presents an analysis of the test results.
- Chapter 5 presents conclusions and recommendations of this study.
- Appendix A, Appendix B, and Appendix C present the details of data collected in the study.

2 TEST SECTIONS AND TEST METHODS

2.1 Test Sections

This report provides an update on pavement sections previously measured in separate studies. CRCP pavements, surfaced with either longitudinal tining (LT) or CDG, were added to the last year of data collection of the portland cement concrete (PCC) noise study (*3*). A separate report evaluated the GnG surfaces of several pilot projects of JPCP, often directly comparing the GnG sections with adjacent CDG pavements (*5*).

2.1.1 Continuously Reinforced Concrete Pavement Sections

For the fourth year of the concrete noise study in 2012, Caltrans added six CRCP projects to the list of sites, listed in Table 2.1. Only five of the sections were constructed before this evaluation in 2012, as the San Joaquin-5 project was accepted in March 2017. For each CRCP project, like the other noise study locations, a single 0.1 mi. section was selected.

Table 2.1: List of Continuously Reinforced Concrete Pavement Sections

Noise Section ID	Section County	Section Route	Section Direction	Section Lane	Section Start Post Mile
ES 176 (QP 203)	Placer	80	East	Lane 1	PM 56.45
ES 177	Siskiyou	5	North	Lane 2	PM 57.0
ES 178	Kern	5	South	Lane 2	PM 40.0
ES 179	San Joaquin	5	North	Lane 1	PM 32.0
ES 180	Imperial	78	East	Lane 2	PM R15.0
ES 181	Imperial	86	South	Lane 2	PM R24.2

2.1.2 California Grind and Groove (GnG) Pilot Projects

In 2010 and 2011, Caltrans selected seven concrete pavement preservation projects scheduled for CDG to pilot the GnG technology. Within each project's limits, a one- to two-mile section was selected for the GnG construction, leaving CDG sections adjacent to GnG to be used for comparison of acoustical performance. The seven projects are listed in Table 2.2.

Table 2.2: List of Grind and Groove (GnG) Pilot Projects

Project EA[a]	Project County	Project Route	Project Post Mile Limits	CDG Evaluation Post Mile Limits	GnG Evaluation Post Mile Limits
1F450[b]	Sacramento	5	PM 17.2/ PM 22.8	PM 20.0 – 21.5 Southbound Lanes 1 and 4	PM 20.0 – 21.5 Northbound Lanes 1 and 4
0F590[b]	Sacramento	5	PM 0.0/ PM 3.5	PM 1.5 – 3.0 Southbound Lanes 1 and 2	PM 1.5 – 3.0 Northbound Lanes 1 and 2
2F040	Sacramento	80	PM 12.4/ PM 18.0	n/a	PM 13.0 – 14.0 Eastbound and Westbound Lanes 2 and 5
0A800[b]	Sacramento	50	PM R12.2/ PM R14.2	PM R13.0 – R14.0 Eastbound Lanes 2 and 4	PM R13.0 – R14.0 Westbound Lanes 2 and 4
0V870	San Joaquin	99	PM 29.0/ PM 30.8 NB	n/a	PM 29.0 – 30.7 Northbound Lanes 1 and 2
2F050	Yolo	113	PM R0.0/ PM R11.1	PM R1.5 – R2.5 Northbound and PM R0.9 – R2.5 Southbound Lanes 1 and 2	PM R0.5 - R1.5 Northbound and PM R0.5 – R0.9 Southbound Lanes 1 and 2
07760 and 07980	San Diego	5	PM R36.3/ PM R37.4	PM R35.8 – R36.3 PM R37.4 – R37.9 Northbound and Southbound Lanes 1 through 5	PM R36.35 – R37.35 Northbound and Southbound Lanes 1 through 5

[a] EA: Expenditure Authorization serves as the Caltrans project identification number.
[b] Project had additional segments outside the reported project limits.

The initial evaluation involved measurements of noise and longitudinal profiles in the right wheelpaths before and after CDG and GnG construction. In this study the post construction data collected between 2012 and 2013 will be compared with data collected in 2016 and 2017.

2.1.3 List of Evaluation Test Sections

Each CRCP location is a single section, and each GnG project has several sub-sections. The list of test sections is shown in Table 2.3. The location is shown along with:

- Section length in miles
- Pavement type, either CRCP or JPCP
- Surface texture of either longitudinal tining (LT), conventional diamond grinding (CDG) or grind and groove (GnG)
- Lane type, either passenger (P) or truck (T); truck lanes include:
    - Highways with one lane in each direction
    - Right-most lane of highways with two or three lanes in one direction
    - Two right-most lanes of roads with four or more lanes in one direction
- Climate region
- Date of the last retexturing

Table 2.3: List of Evaluated Test Sections

Test Section Location	Length (mi.)	Pavement Type[a]	Surface Texture[b]	Lane Type[c]	Climate Region	Last Retexturing
Pla80E1PM56.45	0.1	CRCP	LT	P	High Mountain	4/1/2012
Sis5N2PM57.0	0.1	CRCP	CDG	T	High Desert	9/26/2007
Ker5S2PM40.0	0.1	CRCP	LT	T	Inland Valley	8/23/2010
SJ5N1PM32.0	0.1	CRCP	CDG	P	Inland Valley	1/26/2017
Imp78E2PMR15.0	0.1	CRCP	LT	T	Desert	1/1/2012
Imp86S2PMR24.2	0.1	CRCP	LT	T	Desert	1/2/2012
Sac5N1PM20.0	1.5	JPCP	GnG	P	Inland Valley	7/1/2011
Sac5N4PM20.0	1.5	JPCP	GnG	T	Inland Valley	7/1/2011
Sac5S1PM21.5	1.5	JPCP	CDG	P	Inland Valley	7/1/2011
Sac5S4PM21.5	1.5	JPCP	CDG	T	Inland Valley	7/1/2011
Sac5N1PM1.5	1.5	JPCP	GnG	P	Inland Valley	12/1/2011
Sac5N2PM1.5	1.5	JPCP	GnG	T	Inland Valley	12/1/2011
Sac5S1PM3.0	1.5	JPCP	CDG	P	Inland Valley	12/1/2011
Sac5S2PM3.0	1.5	JPCP	CDG	T	Inland Valley	12/1/2011
Sac80E2PM13.0	1.0	JPCP	GnG	P	Inland Valley	5/1/2012
Sac80E5PM13.0	1.0	JPCP	GnG	T	Inland Valley	5/1/2012
Sac80W2PM14.0	1.0	JPCP	GnG	P	Inland Valley	5/1/2012
Sac80W5PM14.0	1.0	JPCP	GnG	T	Inland Valley	5/1/2012
Sac50E2PM13.0	1.0	JPCP	CDG	P	Inland Valley	6/1/2012
Sac50E4PM13.0	1.0	JPCP	CDG	T	Inland Valley	6/1/2012
Sac50W2PM14.0	1.0	JPCP	GnG	P	Inland Valley	6/1/2012
Sac50W4PM14.0	1.0	JPCP	GnG	T	Inland Valley	6/1/2012
SJ99N1PM29.0	1.7	JPCP	GnG	P	Inland Valley	7/1/2012
SJ99N2PM29.0	1.7	JPCP	GnG	T	Inland Valley	7/1/2012

Test Section Location	Length (mi.)	Pavement Type[a]	Surface Texture[b]	Lane Type[c]	Climate Region	Last Retexturing
Yol113N1PM0.5	1.0	JPCP	GnG	P	Inland Valley	4/1/2012
Yol113N2PM0.5	1.0	JPCP	GnG	T	Inland Valley	4/1/2012
Yol113S1PM0.9	0.5	JPCP	GnG	P	Inland Valley	4/1/2012
Yol113S2PM0.9	0.5	JPCP	GnG	T	Inland Valley	4/1/2012
Yol113N1PM1.5	1.0	JPCP	CDG	P	Inland Valley	4/1/2012
Yol113N2PM1.5	1.0	JPCP	CDG	T	Inland Valley	4/1/2012
Yol113S1PM2.5	1.5	JPCP	CDG	P	Inland Valley	4/1/2012
Yol113S2PM2.5	1.5	JPCP	CDG	T	Inland Valley	4/1/2012
SD5N1PM36.4	1.0	JPCP	GnG	P	South Coast	7/1/2012
SD5N2PM36.4	1.0	JPCP	GnG	P	South Coast	7/1/2012
SD5N3PM36.4	1.0	JPCP	GnG	P	South Coast	7/1/2012
SD5N4PM36.4	1.0	JPCP	GnG	T	South Coast	7/1/2012
SD5N5PM36.4	1.0	JPCP	GnG	T	South Coast	7/1/2012
SD5S1PM37.3	1.0	JPCP	GnG	P	South Coast	7/1/2012
SD5S2PM37.3	1.0	JPCP	GnG	P	South Coast	7/1/2012
SD5S3PM37.3	1.0	JPCP	GnG	P	South Coast	7/1/2012
SD5S4PM37.3	1.0	JPCP	GnG	T	South Coast	7/1/2012
SD5S5PM37.3	1.0	JPCP	GnG	T	South Coast	7/1/2012
SD5N1PM35.8/37.4	1.0	JPCP	CDG	P	South Coast	4/1/2011
SD5N2PM35.8/37.4	1.0	JPCP	CDG	P	South Coast	4/1/2011
SD5N3PM35.8/37.4	1.0	JPCP	CDG	P	South Coast	4/1/2011
SD5N4PM35.8/37.4	1.0	JPCP	CDG	T	South Coast	4/1/2011
SD5N5PM35.8/37.4	1.0	JPCP	CDG	T	South Coast	4/1/2011
SD5S1PM37.9/36.3	1.0	JPCP	CDG	P	South Coast	4/1/2011
SD5S2PM37.9/36.3	1.0	JPCP	CDG	P	South Coast	4/1/2011
SD5S3PM37.9/36.3	1.0	JPCP	CDG	P	South Coast	4/1/2011
SD5S4PM37.9/36.3	1.0	JPCP	CDG	T	South Coast	4/1/2011
SD5S5PM37.9/36.3	1.0	JPCP	CDG	T	South Coast	4/1/2011

[a] CRCP is continuously reinforced concrete pavement, and JPCP is jointed plain concrete pavement.
[b] LT is longitudinally tined, CDG is conventional diamond grinding, and GnG is grind and groove.
[c] P is passenger lane, T is truck lane.

2.2 Test Methods

Evaluation of these test sections was conducted with a single vehicle outfitted with equipment to measure both tire/pavement noise and pavement smoothness. The UCPRC test vehicle had microphones set up to measure noise at the passenger-side rear tire and smoothness in the right wheelpath (Figure 2.1).

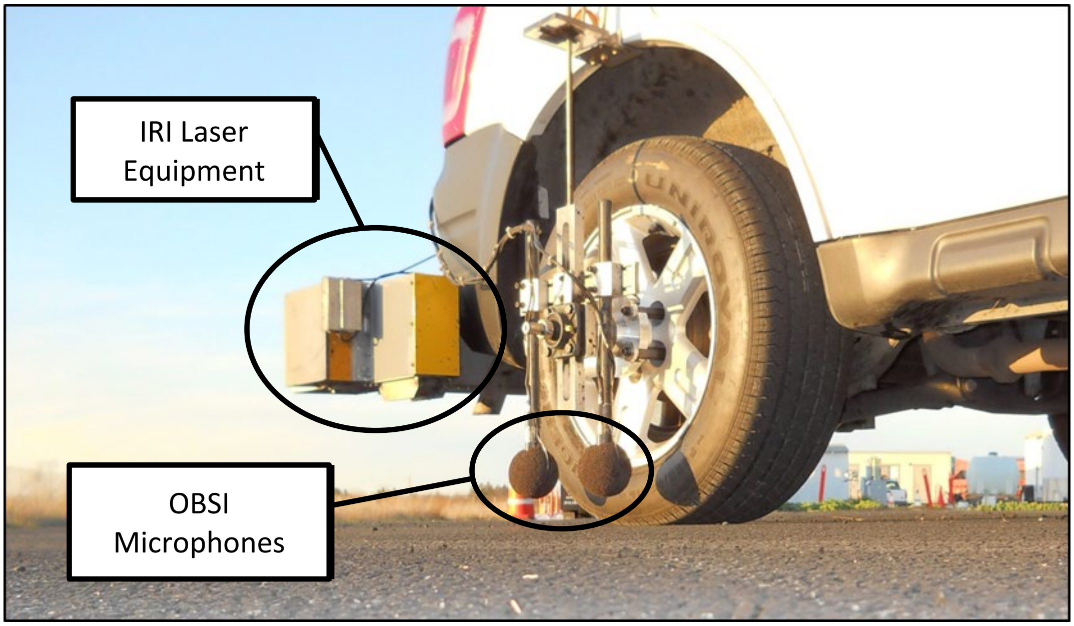


Figure 2.1: The UCPRC OBSI and IRI test vehicle with mounted microphones and laser equipment.

2.2.1 Tire/Pavement Noise Test Method

Tire/pavement noise measurements were collected following AASHTO TP 76, "Measurement of Tire/Pavement Noise Using the On-Board Sound Intensity (OBSI) Method." During data collection in 2016, AASHTO replaced the provisional AASHTO TP 76 with AASHTO T360. The UCPRC OBSI and International Roughness Index (IRI) test vehicle carried equipment for collecting OBSI data in accordance with AASHTO T360 and profile data in accordance with ASTM E950 (described in the following discussion). For OBSI measurement, the test vehicle usually operated at 60 mph and needed to maintain this speed (±1 mph) during the sampling period. Data were typically analyzed in 0.1 mi. long pavement sections following standard OBSI procedures. The GnG test sections were 1 to 2 mi. long.

The OBSI method measured sound intensity levels in one-third octave bands, from the frequency centered at 400 Hz to the frequency centered at 5,000 Hz. These values were obtained at the leading and trailing edges of the tire/pavement contact patch. Three replicate passes were conducted at each test section to account for lateral variability and speed deviations from the 60 mph (96 km/h) specification. Measurements from the three passes at the two probe locations (leading and trailing) were used to obtain noise spectra, which were in turn used to calculate an overall sound intensity level, the single value that summarizes the overall tire/pavement noise. The sound intensity levels at the leading and trailing edges were averaged through the energy method (*7*). The sound intensity was reported in dBA, with the A rating assigning greater weights to the frequencies that are perceived more by human hearing (*6*).

An air density correction was applied to the overall sound intensity level to account for the effect of air density on the speed of sound. Air density is calculated from atmospheric data collected during testing, including air temperature, barometric pressure, and relative humidity, as well as the altitude of the section.

In addition to the pavement texture, the OBSI levels presented in this report include the effects of joint slap, faulting, and sealant overbanding. CDG processes remove faulting and existing sealant overbanding from the surface, which removes their effects from CDG and GnG OBSI measurements; however, over time, these effects can recur. If present, joint slap, faulting, and sealant overbanding would increase the OBSI level above the level caused by the texture alone. Joint slap is primarily a function of the empty cross-sectional area of the joint below the surface amplifying the sound of the tire passing over the joint. The size of the joint will fluctuate throughout the day as daily temperature changes impact the slab. Similarly, faulting causes noise as the tire passes over a fault. Sealant overbanding is the presence of joint sealant above the surface of a joint, which creates positive texture that results in noise increase from tire vibration (*8*).

2.2.2 Roughness Test Method

Roughness measurements were calculated following ASTM E1926, "Computing International Roughness Index of Roads from Longitudinal Profile Measurements." The UCPRC test vehicle carried equipment for measuring inertial profiler equipment while OBSI was being measured, with the longitudinal profiles used for IRI collected in accordance with ASTM E950, "Measuring the Longitudinal Profiles of Traveled Surfaces with an Accelerometer Established Inertial Profiling Reference." The IRI was measured in the right wheelpath with a high-speed point laser measuring at 60 kHz and a wide-spot (Roline™) laser measuring at 3 kHz, both of which were attached to the rear of the test vehicle (Figure 2.1). All IRI data in this report are from the wide-spot laser.

3 TEST RESULTS

In this chapter, traffic and OBSI and IRI test results are presented for each section. The traffic volumes are provided for 2012 to 2016 followed by the test results from OBSI and IRI data collected in 2012 and 2016. Following the traffic data is a table with the environmental conditions measured during sampling. As described in the previous discussion, the OBSI and IRI data are the average and standard deviation of three replicate passes. Appendix A and Appendix B present figures of the OBSI and IRI over the length of each test section.

Caltrans traffic data were selected from the closest intersections or interchanges on either side of the test section according to the post mile (*9*). In the traffic count tables, the traffic leg indicates whether the volumes are in the direction of increasing post mile numbers, A, or decreasing post mile numbers, B. Also shown are the vehicle and truck counts, the truck percentage, and the two-way equivalent axle loads.

Because the traffic data and environmental conditions during sampling are the same for many JPCP test sections that are adjacent to each other, the section results are grouped. The CRCP sections show one set of traffic and environmental data for one test section. The JPCP sections are then shown, grouped by GnG pilot project, with one set of traffic and environmental data for several test sections where the traffic and sampling conditions are the same.

3.1 Continuously Reinforced Concrete Pavement (CRCP) Sections

3.1.1 Placer 80 EB Lane 1 – PM 56.45 – CRCP with Longitudinally Tined Surface

The Pla80E1PM56.45 test section was mistakenly labeled as Nev80 E1PM56.45 in previous reports due to its meandering along the border between Placer County and Nevada County.

Table 3.1 presents the traffic and truck volumes for the Placer 80 section for the even years between 2012 and 2016. The traffic counts are from the intersection with Route 174, at PM 33.131 in Colfax, and the intersection with Route 20, at PM R59.54. Like other CRCP sections over this time period, the vehicle and truck counts increased by about 20% (19% and 22% for these separate legs).

Table 3.1: Traffic and Truck Counts on Placer 80 – PM 33.131 and PM R59.54

Post Mile	Traffic Leg	Year	Vehicle AADT	Truck AADT	Trucks (%)	Two-Way Equivalent Axle Loads
PM 33.131	A	2012	25,000	4,738	18.95	1,169,000
PM 33.131	A	2014	26,500	5,023	18.95	1,239,000
PM 33.131	A	2016	29,800	5,647	18.95	1,393,000
PM R59.54	B	2012	23,500	5,053	21.50	1,247,000
PM R59.54	B	2014	24,900	5,354	21.50	1,321,000
PM R59.54	B	2016	28,700	6,171	21.50	1,522,000

Table 3.2 summarizes the test results for this section and Table 3.3 provides the environmental conditions while sampling. The 2013 pavement temperature was not collected.

Table 3.2: Summary of Test Results for Placer 80 EB Lane 1 – PM 56.45

Date	Average, OBSI (dBA)	Std. Dev., OBSI (dBA)	Average, IRI (in./mi.)	Std. Dev., IRI (in./mi.)
11/14/2013	106.7	0.4	74.3	1.0
10/21/2016	109.1	0.6	90.5	10.0

Table 3.3: Environmental Conditions While Sampling Placer 80 EB Lane 1 – PM 56.45

Date	Time (24 hr)	Air Temp. (°F)	Pavement Temp. (°F)	Relative Humidity (%)	Barometric Pressure (mm Hg)
11/14/2013	15:12	59	—	34	30.06
10/21/2016	15:24	65	76	32	29.89

3.1.2 Siskiyou 5 NB Lane 2 – PM R57.0 – CRCP with Conventional Diamond Grind Surface

Table 3.4 presents the traffic and truck volumes for Siskiyou 5 for the even years between 2012 and 2016. The traffic counts are from the intersection with Route 3, at PM 48.239 in Yreka, and the intersection with Route 96 West, at PM R58.326. Like other CRCP sections over these years, the truck counts increased by approximately 20% (29% and 12% for the separate legs).

Table 3.4: Traffic and Truck Counts on Siskiyou 5 – PM 48.239 and PM R58.326

Post Mile	Traffic Leg	Year	Vehicle AADT	Truck AADT	Trucks (%)	Two-Way Equivalent Axle Loads
PM 48.239	A	2012	15,200	3,944	25.95	1,193,000
PM 48.239	A	2014	13,400	4,035	30.11	1,291,000
PM 48.239	A	2016	15,600	5,078	32.55	1,624,000
PM R58.326	A	2012	15,800	4,196	26.56	1,269,000
PM R58.326	A	2014	13,900	4,003	28.80	1,283,000
PM R58.326	A	2016	16,800	4,692	27.93	1,485,000

Table 3.5 summarizes the test results for this section, and Table 3.6 provides the environmental conditions while sampling. The 2013 pavement temperature was not collected.

Table 3.5: Summary of Test Results for Siskiyou 5 NB Lane 2 – PM R57.0

Date	Average, OBSI (dBA)	Std. Dev., OBSI (dBA)	Average, IRI (in./mi.)	Std. Dev., IRI (in./mi.)
3/28/2013	104.3	0.4	64.8	2.5
10/20/2016	105.0	0.1	49.5	2.7

Table 3.6: Environmental Conditions While Sampling Siskiyou 5 NB Lane 2 – PM R57.0

Date	Time (24 hr)	Air Temp. (°F)	Pavement Temp. (°F)	Relative Humidity (%)	Barometric Pressure (mm Hg)
3/28/2013	9:41	48	—	91	30.02
10/20/2016	14:45	68	78	57	30.25

3.1.3 Kern 5 SB Lane 2 – PM 40.0 – CRCP with Longitudinally Tined Surface

Table 3.7 presents the traffic and truck volumes for Kern 5 for the even years between 2012 and 2016. The traffic counts are from the intersection with Route 43, at PM 41.193, and the intersection with Route 119, at PM 38.793. Like other CRCP sections, the truck counts increased by about 20% (20% and 24% for the separate legs).

Table 3.7: Traffic and Truck Counts on Kern 5 – PM 41.193 and PM 38.793

Post Mile	Traffic Leg	Year	Vehicle AADT	Truck AADT	Trucks (%)	Two-Way Equivalent Axle Loads
PM 41.193	B	2012	30,500	8,561	28.07	2,233,000
PM 41.193	B	2014	34,500	9,602	27.83	2,505,000
PM 41.193	B	2016	38,000	10,260	27.00	2,722,000
PM 38.793	A	2012	30,500	8,561	28.07	2,233,000
PM 38.793	A	2014	34,500	9,601	27.83	2,505,000
PM 38.793	A	2016	38,000	10,575	27.83	2,759,000

Table 3.8 summarizes the test results for this section, and Table 3.9 provides the environmental conditions while sampling.

Table 3.8: Summary of Test Results for Kern 5 SB Lane 2 – PM 40.0

Date	Average, OBSI (dBA)	Std. Dev., OBSI (dBA)	Average, IRI (in./mi.)	Std. Dev., IRI (in./mi.)
12/19/2012	111.6	0.2	89.5	1.2
11/18/2016	111.6	0.7	77.4	0.3

Table 3.9: Environmental Conditions While Sampling Kern 5 SB Lane 2 – PM 40.0

Date	Time (24 hr)	Air Temp. (°F)	Pavement Temp. (°F)	Relative Humidity (%)	Barometric Pressure (mm Hg)
12/19/2012	10:53	48	54	45	30.34
11/18/2016	13:59	73	78	21	29.98

3.1.4 San Joaquin 5 NB Lane 1 – PM 31.5/32.7 – CRCP with Conventional Diamond Grind Surface

Table 3.10 presents the traffic and truck volumes for San Joaquin 5 for 2016. The traffic counts are from the intersection with March Lane, at PM 29.99, and the intersection with Hammer Lane, at PM 32.664. The section was built between 2013 and 2017.

Table 3.10: Traffic and Truck Counts on San Joaquin 5 – PM 29.99 and PM 32.66

Post Mile	Traffic Leg	Year	Vehicle AADT	Truck AADT	Trucks (%)	Two-Way Equivalent Axle Loads
PM 29.99	A	2016	106,000	24,381	23.0	6,929,000
PM 32.664	A	2016	73,000	16,498	22.6	4,677,000

Table 3.11 summarizes the test results for this section and Table 3.12 provides the environmental conditions while sampling.

Table 3.11: Summary of Test Results for San Joaquin 5 NB Lane 1 – PM 31.5

Date	Average, OBSI (dBA)	Std. Dev., OBSI (dBA)	Average, IRI (in./mi.)	Std. Dev., IRI (in./mi.)
No Earlier Test	—	—	—	—
6/6/2017	103.6	0.8	64.1	0.9

Table 3.12: Environmental Conditions While Sampling San Joaquin 5 NB Lane 1 – PM 31.5

Date	Time (24 hr)	Air Temp. (°F)	Pavement Temp. (°F)	Relative Humidity (%)	Barometric Pressure (mm Hg)
No Earlier Test	—	—	—	—	—
6/6/2017	11:55	86	103	27	29.88

3.1.5 Imperial 78 EB Lane 2 – PM R15.0 – CRCP with Longitudinally Tined Surface

Table 3.13 presents the traffic and truck volumes for Imperial 78 for the even years between 2012 and 2016. The traffic counts are from the west junction of Route 78 and Route 111, at PM R12.891, and the east junction of Route 78 and Route 111, at PM 15.499. Although outside the test section, the intersection of Imperial 78 and Imperial 111 was realigned in 2012, and there are no traffic data for that year. Therefore, 2013 data are presented instead.

Since the realignment in 2012, the traffic volumes have increased more here than any other section sampled. The truck volumes increased 77% in the west junction intersection and over 700% in the east junction intersection. The surprising increase likely arises from the realignment and its proximity to the international border at Calexico, 30 miles to the south. The test section is outside the realignment limits.

Table 3.13: Traffic and Truck Counts on Imperial 78 – PM R12.891 and PM 15.499

Post Mile	Traffic Leg	Year	Vehicle AADT	Truck AADT	Trucks (%)	Two-Way Equivalent Axle Loads
PM R12.891	X	2013	4,250	2,215	52.12	460,000
PM R12.891	X	2014	4,250	2,995	70.47	516,000
PM R12.891	X	2016	7,300	3,924	53.75	691,000
PM 15.499	B	2012	2,600	598	23.00	88,000
PM 15.499	B	2014	7,200	2,394	33.25	494,000
PM 15.499	B	2016	9,400	4,261	45.33	601,000

Table 3.14 summarizes the test results for this section, and Table 3.15 provides the environmental conditions while sampling.

Table 3.14: Summary of Test Results for Imperial 78 EB Lane 2 – PM R15.0

Date	Average, OBSI (dBA)	Std. Dev., OBSI (dBA)	Average, IRI (in./mi.)	Std. Dev., IRI (in./mi.)
8/12/2012	101.6	0.1	54.0	0.4
11/19/2016	101.8	0.8	70.0	4.1

Table 3.15: Environmental Conditions While Sampling Imperial 78 EB Lane 2 – PM R15.0

Date	Time (24 hr)	Air Temp. (°F)	Pavement Temp. (°F)	Relative Humidity (%)	Barometric Pressure (mm Hg)
8/12/2012	17:15	117	129	48	29.59
11/19/2016	12:19	71	85	30	30.06

3.1.6 Imperial 86 SB Lane 2 – PM R24.2 – CRCP with Longitudinally Tined surface

Table 3.16 presents the traffic and truck volumes for Imperial 86 for the even years between 2012 and 2016. The traffic counts are from the intersection with East Main Street and B Street in Westmoreland, at PM R27.211, and the junction with Imperial 78, at PM R24.057. The intersection of Imperial 78 and

Imperial 111 was realigned in 2012, and there are no data for the junction with Imperial 78 that year. Therefore, 2013 data are presented instead.

The truck and traffic counts from the intersection with East Main Street and B Street, at PM R27.211, decreased by 8%. The truck counts at the junction with Imperial 78 decreased by over 30%, likely arising from the realignment.

Table 3.16: Traffic and Truck Counts on Imperial 86 – PM R27.211 and R24.057

Post Mile	Traffic Leg	Year	Vehicle AADT	Truck AADT	Trucks (%)	Two-Way Equivalent Axle Loads
PM R27.211	B	2012	10,300	2,926	28.41	696,000
PM R27.211	B	2014	9,600	2,726	28.41	648,000
PM R27.211	B	2016	9,500	2,700	28.41	642,000
PM R24.057	B	2013	6,200	1,116	18.00	240,000
PM R24.057	B	2014	5,500	895	16.27	177,000
PM R24.057	B	2016	5,400	764	14.15	135,000

Table 3.17 summarizes the test results for this section, and Table 3.18 provides the environmental conditions while sampling.

Table 3.17: Summary of Test Results for Imperial 86 SB Lane 2 – PM R24.2

Date	Average, OBSI (dBA)	Std. Dev., OBSI (dBA)	Average, IRI (in./mi.)	Std. Dev., IRI (in./mi.)
8/12/2012	104.1	0.3	50.3	1.1
11/19/2016	103.6	0.8	51.2	1.2

Table 3.18: Environmental Conditions While Sampling Imperial 86 SB Lane 2 – PM R24.2

Date	Time (24 hr)	Air Temp. (°F)	Pavement Temp. (°F)	Relative Humidity (%)	Barometric Pressure (mm Hg)
8/12/2012	18:30	108	119	48	29.60
11/19/2016	12:19	71	85	30	30.06

3.2 Sacramento 5 – PM 20.0/21.5 – Grind and Groove Versus Conventional Diamond Grind Surface

Table 3.19 presents the traffic and truck volumes for Sacramento 5 for the even years between 2012 and 2016. The traffic counts are from the intersection at Pocket Road and Meadowview Road, at PM 16.147, and the intersection with Route 50, at PM R22.565. The traffic and truck volumes grew 10% in both legs. While the southbound vehicle counts, shown by the B leg, exceed the northbound volumes by about 40%, the truck counts and two-way equivalent axle loads are very similar in both directions.

Table 3.19: Traffic and Truck Counts on Sacramento 5 – PM 16.147 and PM 22.565

Post Mile	Traffic Leg	Year	Vehicle AADT	Truck AADT	Trucks (%)	Two-Way Equivalent Axle Loads
PM 16.147	A	2012	101,000	13,342	13.2	3,475,000
PM 16.147	A	2014	101,000	13,343	13.2	3,475,000
PM 16.147	A	2016	111,700	14,756	13.2	3,844,000
PM 22.565	B	2012	142,000	13,632	9.6	3,403,000
PM 22.565	B	2014	142,000	13,631	9.6	3,403,000
PM 22.565	B	2016	156,200	14,996	9.6	3,744,000

Table 3.20 provides the environmental conditions while sampling Sacramento 5 – PM 20.0/21.5.

Table 3.20: Environmental Conditions While Sampling Sacramento 5 – PM 20.0/21.5

Date	Time (24 hr)	Air Temp. (°F)	Pavement Temp. (°F)	Relative Humidity (%)	Barometric Pressure (mm Hg)
1/25/2012	12:21	61	66	68	30.38
1/25/2012	15:20	63	67	59	30.31
5/1/2017	11:45	79	85	41	29.92
5/1/2017	14:52	91	104	20	29.92

3.2.1 Sacramento 5 NB Lane 1 – PM 20.0 – JPCP with GnG

Table 3.21 summarizes the test results for this section.

Table 3.21: Summary of Test Results for Sacramento 5 NB Lane 1 – PM 20.0

Date	Average, OBSI (dBA)	Std. Dev., OBSI (dBA)	Average, IRI (in./mi.)	Std. Dev., IRI (in./mi.)
1/25/2012	102.5	0.5	42.0	0.4
5/1/2017	103.5	0.6	45.9	0.5

3.2.2 Sacramento 5 NB Lane 4 – PM 20.0 – JPCP with GnG

Table 3.22 summarizes the test results for this section.

Table 3.22: Summary of Test Results for Sacramento 5 NB Lane 4 – PM 20.0

Date	Average, OBSI (dBA)	Std. Dev., OBSI (dBA)	Average, IRI (in./mi.)	Std. Dev., IRI (in./mi.)
1/25/2012	103.0	0.7	52.0	0.4
5/1/2017	105.2	1.5	64.3	2.3

3.2.3 Sacramento 5 SB Lane 1 – PM 21.5 – JPCP with CDG

Table 3.23 summarizes the test results for this section.

Table 3.23: Summary of Test Results for Sacramento 5 SB Lane 1 – PM 21.5

Date	Average, OBSI (dBA)	Std. Dev., OBSI (dBA)	Average, IRI (in./mi.)	Std. Dev., IRI (in./mi.)
1/25/2012	101.8	0.4	84.2	1.3
5/1/2017	103.2	0.5	78.9	0.7

3.2.4 Sacramento 5 SB Lane 4 – PM 21.5 – JPCP with CDG

Table 3.24 summarizes the test results for this section.

Table 3.24: Summary of Test Results for Sacramento 5 SB Lane 4 – PM 21.5

Date	Average, OBSI (dBA)	Std. Dev., OBSI (dBA)	Average, IRI (in./mi.)	Std. Dev., IRI (in./mi.)
1/25/2012	103.0	0.7	75.1	0.1
5/1/2017	104.9	0.7	100.9	1.9

3.3 Sacramento 5 – PM 1.5/3.0 – Grind and Groove Versus Conventional Diamond Grind Surface

Table 3.25 presents the traffic and truck volumes for Sacramento 5 for the even years between 2012 and 2016. The traffic counts are from the San Joaquin County Line, at PM 0.018, and the intersection with Pocket Road and Meadowview Road, at PM 16.147. The traffic and truck volumes grew only 3% at the county line compared with 10% at the Pocket Road and Meadowview Road intersection. In 2016, the vehicle volumes doubled between the county line and the Pocket Road and Meadowview Road intersection, and they increased another 40% by the junction with State Route 50. Still, the truck volumes were consistent and increased only 10% over these 22 mi. Most trucks that enter the county from San Joaquin County are heading north of State Route 50.

Table 3.25: Traffic and Truck Counts on Sacramento 5 – PM 0.018 and PM 16.147

Post Mile	Traffic Leg	Year	Vehicle AADT	Truck AADT	Trucks (%)	Two-Way Equivalent Axle Loads
PM 0.018	A	2012	54,000	13,144	24.3	3,424,000
PM 0.018	A	2014	50,000	12,170	24.3	3,170,000
PM 0.018	A	2016	55,700	13,557	24.3	3,531,000
PM 16.147	A	2012	101,000	13,342	13.2	3,475,000
PM 16.147	A	2014	101,000	13,343	13.2	3,475,000
PM 16.147	A	2016	111,700	14,756	13.2	3,844,000

Table 3.26 provides the environmental conditions while sampling Sacramento 5 – PM 1.5/3.0. The air temperature in 2012 was not collected.

Table 3.26: Environmental Conditions While Sampling Sacramento 5 – PM 1.5/3.0

Date		Time (24 hr)	Air Temp. (°F)	Pavement Temp. (°F)	Relative Humidity (%)	Barometric Pressure (mm Hg)
2/6/2012		15:04	—	65	45	29.80
2/6/2012		15:42	—	68	36	29.80
5/2/2017		11:21	86	97	38	29.94
5/2/2017		12:44	90	101	39	29.94
6/6/2017		16:03	91	104	29	29.83

3.3.1 Sacramento 5 NB Lane 1 – PM 1.5 – JPCP with GnG

Table 3.27 summarizes the test results for this section.

Table 3.27: Summary of Test Results for Sacramento 5 NB Lane 1 – PM 1.5

Date	Average, OBSI (dBA)	Std. Dev., OBSI (dBA)	Average, IRI (in./mi.)	Std. Dev., IRI (in./mi.)
2/6/2012	101.7	0.3	42.7	0.2
6/6/2017	103.9	0.8	46.7	6.9

3.3.2 Sacramento 5 NB Lane 2 – PM 1.5 – JPCP with GnG

Table 3.28 summarizes the test results for this section. Unfortunately, the IRI data from the 2017 sample collection was inaccessible.

Table 3.28: Summary of Test Results for Sacramento 5 NB Lane 2 – PM 1.5

Date	Average, OBSI (dBA)	Std. Dev., OBSI (dBA)	Average, IRI (in./mi.)	Std. Dev., IRI (in./mi.)
2/6/2012	102.1	0.4	48.2	0.7
5/2/2017	105.1	0.8	—	—

3.3.3 Sacramento 5 SB Lane 1 – PM 3.0 – JPCP with CDG

Table 3.29 summarizes the test results for this section.

Table 3.29: Summary of Test Results for Sacramento 5 SB Lane 1 – PM 3.0

Date	Average, OBSI (dBA)	Std. Dev., OBSI (dBA)	Average, IRI (in./mi.)	Std. Dev., IRI (in./mi.)
2/6/2012	103.4	0.4	62.8	0.2
6/6/2017	103.9	0.3	60.7	1.5

3.3.4 Sacramento 5 SB Lane 2 – PM 3.0 – JPCP with CDG

Table 3.30 summarizes the test results for this section.

Table 3.30: Summary of Test Results for Sacramento 5 SB Lane 2 – PM 3.0

Date	Average, OBSI (dBA)	Std. Dev., OBSI (dBA)	Average, IRI (in./mi.)	Std. Dev., IRI (in./mi.)
2/6/2012	103.6	0.8	64.7	0.5
5/2/2017	104.4	0.7	60.7	1.4

3.4 Sacramento 80 – PM 13.0/14.0 – Grind and Groove Surface Only

Table 3.31 presents the traffic and truck volumes for Sacramento 80 for the even years between 2012 and 2016. The traffic counts are from the junction with Route 51, at PM R10.989, and the intersection with Greenback Lane, at PM 14.454. Between 2012 and 2016, truck volumes grew less than 5%.

Table 3.31: Traffic and Truck Counts on Sacramento 80 – PM R10.989 and PM 14.45

Post Mile	Traffic Leg	Year	Vehicle AADT	Truck AADT	Trucks (%)	Two-Way Equivalent Axle Loads
PM R10.989	A	2012	211,000	8,208	3.9	1,871,000
PM R10.989	A	2014	195,000	7,585	3.9	1,729,000
PM R10.989	A	2016	220,500	8,578	3.9	1,955,000
PM 14.454	A	2012	177,000	8,868	5.0	1,983,000
PM 14.454	A	2014	177,000	8,144	4.6	1,895,000
PM 14.454	A	2016	191,400	8,746	4.6	2,032,000

Table 3.32 provides the environmental conditions while sampling Sacramento 80 – PM 13.0/14.0. The pavement temperature and relative humidity were not collected in 2012.

Table 3.32: Environmental Conditions While Sampling Sacramento 80 – PM 13.0/14.0

Date	Time (24 hr)	Air Temp. (°F)	Pavement Temp. (°F)	Relative Humidity (%)	Barometric Pressure (mm Hg)
5/29/2012	14:48	84	—	—	29.98
11/10/2016	11:52	71	82	64	30.10

3.4.1 Sacramento 80 EB Lane 2 – PM 13.0 – JPCP with GnG

Table 3.33 summarizes the test results for this section.

Table 3.33: Summary of Test Results for Sacramento 80 EB Lane 2 – PM 13.0

Date	Average, OBSI (dBA)	Std. Dev., OBSI (dBA)	Average, IRI (in./mi.)	Std. Dev., IRI (in./mi.)
5/29/2012	101.8	0.3	33.9	0.8
11/10/2016	103.7	0.3	44.6	0.4

3.4.2 Sacramento 80 EB Lane 5 – PM 13.0 – JPCP with GnG

Table 3.34 summarizes the test results for this section.

Table 3.34: Summary of Test Results for Sacramento 80 EB Lane 5 – PM 13.0

Date	Average, OBSI (dBA)	Std. Dev., OBSI (dBA)	Average, IRI (in./mi.)	Std. Dev., IRI (in./mi.)
5/29/2012	101.8	0.3	41.6	0.8
11/10/2016	103.0	0.3	48.9	1.1

3.4.3 Sacramento 80 WB Lane 2 – PM 14.0 – JPCP with GnG

Table 3.35 summarizes the test results for this section.

Table 3.35: Summary of Test Results for Sacramento 80 WB Lane 2 – PM 14.0

Date	Average, OBSI (dBA)	Std. Dev., OBSI (dBA)	Average, IRI (in./mi.)	Std. Dev., IRI (in./mi.)
5/29/2012	101.7	0.3	41.9	0.3
11/10/2016	103.1	0.4	45.8	0.7

3.4.4 Sacramento 80 WB Lane 5 – PM 14.0 – JPCP with GnG

Table 3.36 summarizes the test results for this section.

Table 3.36: Summary of Test Results for Sacramento 80 WB Lane 5 – PM 14.0

Date	Average, OBSI (dBA)	Std. Dev., OBSI (dBA)	Average, IRI (in./mi.)	Std. Dev., IRI (in./mi.)
5/29/2012	102.0	0.4	47.7	0.7
11/10/2016	102.9	0.4	66.3	0.9

3.5 Sacramento 50 – PM 13.0/14.0 – Grind and Groove Versus Conventional Diamond Grind Surface

Table 3.37 presents the traffic and truck volumes for Sacramento 50 for the even years between 2012 and 2016. The traffic counts are from the intersection of Sunrise Boulevard, at PM 12.496, and the intersection with Nimbus Road, at PM 15.759. Like other JPCP sections, the vehicle and truck counts grew by more than 10% over this time period. The volumes are consistent between the two intersections.

Table 3.37: Traffic and Truck Counts on Sacramento 50 – PM 12.496 and PM 15.759

Post Mile	Traffic Leg	Year	Vehicle AADT	Truck AADT	Trucks (%)	Two-Way Equivalent Axle Loads
PM 12.496	A	2012	116,000	7,424	6.4	1,357,000
PM 12.496	A	2014	116,000	7,425	6.4	1,357,000
PM 12.496	A	2016	129,300	8,275	6.4	1,512,000
PM 15.759	A	2012	110,000	6,930	6.3	1,248,000
PM 15.759	A	2014	119,000	7,497	6.3	1,350,000
PM 15.759	A	2016	126,300	7,957	6.3	1,433,000

Table 3.38 provides the environmental conditions while sampling Sacramento 50 – PM 13.0/14.0. The pavement temperature and relative humidity were not collected in 2012.

Table 3.38: Environmental Conditions While Sampling Sacramento 50 – PM 13.0/14.0

Date	Time (24 hr)	Air Temp. (°F)	Pavement Temp. (°F)	Relative Humidity (%)	Barometric Pressure (mm Hg)
5/30/2012	14:51	89	—	—	30.00
10/24/2016	14:55	70	81	59	29.94

3.5.1 Sacramento 50 EB Lane 2 – PM 13.0 – JPCP with CDG

Table 3.39 summarizes the test results for this section.

Table 3.39: Summary of Test Results for Sacramento 50 EB Lane 2 – PM 13.0

Date	Average, OBSI (dBA)	Std. Dev., OBSI (dBA)	Average, IRI (in./mi.)	Std. Dev., IRI (in./mi.)
5/30/2012	103.0	0.7	77.2	2.6
10/24/2016	103.9	0.9	77.9	1.1

3.5.2 Sacramento 50 EB Lane 4 – PM 13.0 – JPCP with CDG

Table 3.40 summarizes the test results for this section. The initial data from May 2012 were not collected for this section, and the average value from Lane 2 is used for comparison since it was collected immediately after construction.

Table 3.40: Summary of Test Results for Sacramento 50 EB Lane 4 – PM 13.0

Date	Average, OBSI (dBA)	Std. Dev., OBSI (dBA)	Average, IRI (in./mi.)	Std. Dev., IRI (in./mi.)
5/30/2012	103.0	0.0	77.2	0.0
10/24/2016	105.5	0.5	69.6	2.4

3.5.3 Sacramento 50 WB Lane 2– PM 14.0 – JPCP with GnG

Table 3.41 summarizes the test results for this section.

Table 3.41: Summary of Test Results for Sacramento 50 WB Lane 2 – PM 14.0

Date	Average, OBSI (dBA)	Std. Dev., OBSI (dBA)	Average, IRI (in./mi.)	Std. Dev., IRI (in./mi.)
5/30/2012	100.9	0.3	62.6	2.8
10/24/2016	102.7	1.1	62.0	0.9

3.5.4 Sacramento 50 WB Lane 4 – PM 14.0 – JPCP with GnG

Table 3.42 summarizes the test results for this section.

Table 3.42: Summary of Test Results for Sacramento 50 WB Lane 4 – PM 14.0

Date	Average, OBSI (dBA)	Std. Dev., OBSI (dBA)	Average, IRI (in./mi.)	Std. Dev., IRI (in./mi.)
5/30/2012	101.8	0.3	52.3	0.2
10/24/2016	105.6	1.8	81.2	0.9

3.6 San Joaquin 99 – PM 29.0/30.7 – Grind and Groove only

Table 3.43 presents the traffic and truck volumes for San Joaquin 99 for the even years between 2012 and 2016. The traffic counts are from the junction with State Route 12 West, at PM 24.499, and the junction with State Route 12 East, at PM 30.974. While the vehicle counts over this section were among the lowest of the GnG projects (only Yolo 113 and Sacramento 5 – PM 1.5/3.0 had lower AADT), the percentage of trucks (13.4%) was second only to Sacramento 5 – PM 1.5/3.0 (24.3%). The CRCP projects all have truck percentages in excess of 20%.

Table 3.43: Traffic and Truck Counts on San Joaquin 99 – PM 29.499 and PM 30.974

Post Mile	Traffic Leg	Year	Vehicle AADT	Truck AADT	Trucks (%)	Two-Way Equivalent Axle Loads
PM 29.499	A	2012	65,000	8,710	13.4	1,875,000
PM 29.499	A	2014	69,000	9,246	13.4	1,990,000
PM 29.499	A	2016	76,000	10,184	13.4	2,192,000
PM 29.499	B	2012	58,000	7,714	13.3	1,727,000
PM 29.499	B	2014	71,000	9,443	13.3	2,114,000
PM 29.499	B	2016	75,000	9,976	13.3	2,233,000
PM 30.974	A	2012	65,000	8,710	13.4	1,875,000
PM 30.974	A	2014	69,000	9,246	13.4	1,990,000
PM 30.974	A	2016	76,000	10,184	13.4	2,192,000

Table 3.44 provides the environmental conditions while sampling San Joaquin 99 – PM 29.0/30.7. The relative humidity was not collected in 2012.

Table 3.44: Environmental Conditions While Sampling San Joaquin 99 – PM 29.0/30.7

Date	Time (24 hr)	Air Temp. (°F)	Pavement Temp. (°F)	Relative Humidity (%)	Barometric Pressure (mm Hg)
9/14/2012	14:35	91	104	—	29.97
5/4/2017	11:06	88	104	41	29.88

3.6.1 San Joaquin 99 NB Lane 1 – PM 29.0 – JPCP with GnG

Table 3.45 summarizes the test results for this section.

Table 3.45: Summary of Test Results for San Joaquin 99 NB Lane 1 – PM 29.0

Date	Average, OBSI (dBA)	Std. Dev., OBSI (dBA)	Average, IRI (in./mi.)	Std. Dev., IRI (in./mi.)
9/14/2012	100.7	0.8	44.3	1.9
5/4/2017	103.1	0.6	45.5	0.2

3.6.2 San Joaquin 99 NB Lane 2 – PM 29.0 – JPCP with GnG

Table 3.46 summarizes the test results for this section.

Table 3.46: Summary of Test Results for San Joaquin 99 NB Lane 2 – PM 29.0

Date	Average, OBSI (dBA)	Std. Dev., OBSI (dBA)	Average, IRI (in./mi.)	Std. Dev., IRI (in./mi.)
9/14/2012	101.5	1.0	72.9	34.1
5/4/2017	104.5	0.9	83.1	1.4

3.7 Yolo 113 – PM R0.5/R2.5 – Grind and Groove Versus Conventional Diamond Grind Surface

Table 3.47 presents the traffic and truck volumes for the project site for the even years from 2012 through 2016. The traffic counts are from the intersection with Russell Boulevard, at PM 1.082, and the intersection with County Road 29, at PM 4.105. In the table, the traffic leg indicates whether the volumes are in the direction of increasing post mile numbers, A, or decreasing post mile numbers, B. This route had the lowest vehicular and truck volumes of the sections evaluated. Still, these volumes increased about 10% over between 2012 and 2016.

Table 3.47: Traffic and Truck Counts on Yolo 113 – PM R1.082 and PM R4.105

Post Mile	Traffic Leg	Year	Vehicle AADT	Truck AADT	Trucks (%)	Two-Way Equivalent Axle Loads
PM R1.082	B	2012	37,000	1,991	5.4	428,000
PM R1.082	B	2014	39,000	2,098	5.4	451,000
PM R1.082	B	2016	41,200	2,217	5.4	477,000
PM R1.082	A	2012	31,500	1,843	5.9	374,000
PM R1.082	A	2014	32,500	1,900	5.9	386,000
PM R1.082	A	2016	34,400	2,012	5.9	409,000
PM R4.105	A	2012	23,900	1,845	7.7	375,000
PM R4.105	A	2014	23,900	1,485	6.2	334,000
PM R4.105	A	2016	25,500	1,523	6.0	305,000

Table 3.48 provides the environmental conditions while sampling Yolo 113 – PM R0.5/R2.5. The 2013 pavement temperature was not collected.

Table 3.48: Environmental Conditions While Sampling Yolo 113 – PM R0.5/R2.5

Date	Time (24 hr)	Air Temp. (°F)	Pavement Temp. (°F)	Relative Humidity (%)	Barometric Pressure (mm Hg)
7/2/2013	16:30	104	—	25	29.78
7/2/2013	16:22	103	—	33	29.78
10/26/2016	14:31	76	80	51	30.00
10/26/2016	16:10	76	77	47	29.97

3.7.1 Yolo 113 NB Lane 1 – PM 0.5 – JPCP with GnG

Table 3.49 presents the data for this section.

Table 3.49: Summary of Test Results for Yolo 113 NB Lane 1 – PM 0.5

Date	Average, OBSI (dBA)	Std. Dev., OBSI (dBA)	Average, IRI (in./mi.)	Std. Dev., IRI (in./mi.)
7/2/2013	100.6	0.3	53.1	3.9
10/26/2016	102.0	0.4	48.7	1.4

3.7.2 Yolo 113 NB Lane 2 – PM 0.5 – JPCP with GnG

Table 3.50 summarizes the test results for this section.

Table 3.50: Summary of Test Results for Yolo 113 NB Lane 2 – PM 0.5

Date	Average, OBSI (dBA)	Std. Dev., OBSI (dBA)	Average, IRI (in./mi.)	Std. Dev., IRI (in./mi.)
7/2/2013	100.4	0.4	47.6	2.5
10/26/2016	102.6	0.4	52.4	0.1

3.7.3 Yolo 113 SB Lane 1 – PM 0.9 – JPCP with GnG

Table 3.51 summarizes the test results for this section.

Table 3.51: Summary of Test Results for Yolo 113 SB Lane 1 – PM 0.9

Date	Average, OBSI (dBA)	Std. Dev., OBSI (dBA)	Average, IRI (in./mi.)	Std. Dev., IRI (in./mi.)
7/2/2013	100.6	0.2	49.4	0.7
10/26/2016	102.3	0.3	55.5	1.1

3.7.4 Yolo 113 SB Lane 2 – PM 0.9 – JPCP with GnG

Table 3.52 summarizes the test results for this section.

Table 3.52: Summary of Test Results for Yolo 113 SB Lane 2 – PM 0.9

Date	Average, OBSI (dBA)	Std. Dev., OBSI (dBA)	Average, IRI (in./mi.)	Std. Dev., IRI (in./mi.)
7/2/2013	100.4	0.4	53.5	0.7
10/26/2016	102.6	0.4	51.8	3.5

3.7.5 Yolo 113 NB Lane 1 – PM 1.5 – JPCP with CDG

Table 3.53 summarizes the test results for this section.

Table 3.53: Summary of Test Results for Yolo 113 NB Lane 1 – PM 1.5

Date	Average, OBSI (dBA)	Std. Dev., OBSI (dBA)	Average, IRI (in./mi.)	Std. Dev., IRI (in./mi.)
7/2/2013	102.3	0.4	50.2	1.6
10/26/2016	103.2	0.4	46.6	0.8

3.7.6 Yolo 113 NB Lane 2 – PM 1.5 – JPCP with CDG

Table 3.54 summarizes the test results for this section.

Table 3.54: Summary of Test Results for Yolo 113 NB Lane 2 – PM 1.5

Date	Average, OBSI (dBA)	Std. Dev., OBSI (dBA)	Average, IRI (in./mi.)	Std. Dev., IRI (in./mi.)
7/2/2013	101.2	0.3	46.7	0.1
10/26/2016	103.0	0.4	54.5	0.5

3.7.7 Yolo 113 SB Lane 1 – PM 2.5 – JPCP with CDG

Table 3.55 summarizes the test results for this section.

Table 3.55: Summary of Test Results for Yolo 113 SB Lane 1 – PM 2.5

Date	Average, OBSI (dBA)	Std. Dev., OBSI (dBA)	Average, IRI (in./mi.)	Std. Dev., IRI (in./mi.)
7/2/2013	101.4	0.8	55.0	0.0
10/26/2016	102.2	0.5	52.7	0.3

3.7.8 Yolo 113 SB Lane 2 – PM 2.5 – JPCP with CDG

Table 3.56 summarizes the test results for this section.

Table 3.56: Summary of Test Results for Yolo 113 SB Lane 2 – PM 2.5

Date	Average, OBSI (dBA)	Std. Dev., OBSI (dBA)	Average, IRI (in./mi.)	Std. Dev., IRI (in./mi.)
7/2/2013	101.2	0.3	68.3	1.2
10/26/2016	103.0	0.4	74.9	1.7

3.8 San Diego 5 – PM 35.8/37.9 – Grind and Groove Versus Conventional Diamond Grind Surface

All the lanes in both directions of San Diego 5 were chosen for OBSI and IRI evaluation; originally, it was to be the only GnG pilot project. One mile of GnG surfacing between PM36.35 and PM37.35 served as the GnG sections, and the half mile of CDG surface both north and south of the GnG section, between PMs R37.4 and R37.9 and PMs R35.8 and R36.3, were used for comparison. The pavement structure has PCC from three different construction periods: Lane 1 was constructed in the 2000s, Lanes 2 and 3 were constructed in the 1960s, and Lanes 4 and 5 were constructed in the 1970s.

Table 3.57 presents the traffic and truck volumes for the San Diego 5. The traffic counts are from the Route 805 North junction (at PM R30.682) and from the intersection of Leucadia Boulevard (at PM R42.712). Between these two locations over this period, there was no significant increase in vehicular traffic (1%) and a 10% decrease in truck traffic. In 2012, southbound truck traffic exceeded northbound truck traffic by almost 60%. By 2016, with a 50% reduction in northbound truck counts, the southbound truck traffic was over 3.5 times the northbound truck traffic.

Table 3.57: Traffic and Truck Counts on San Diego 5 – PM R30.682 and PM R42.712

Post Mile	Traffic Leg	Year	Vehicle AADT	Truck AADT	Trucks (%)	Two-Way Equivalent Axle Loads
PM R30.682	A	2012	150,000	5,700	3.8	1,045,000
PM R30.682	A	2014	75,000	2,850	3.8	1,045,000
PM R30.682	A	2016	150,000	2,850	3.8	522,000
PM R42.712	B	2012	206,000	9,002	4.4	1,718,000
PM R42.712	B	2014	213,000	9,791	4.6	1,717,000
PM R42.712	B	2016	211,000	10,174	4.8	1,795,000

Table 3.58 provides the environmental conditions while sampling San Diego 5 – PM 35.8/37.9. The relative humidity in 2012 was not collected.

Table 3.58: Environmental Conditions While Sampling San Diego 5 – PM 35.8/37.9

Date	Time (24 hr)	Air Temp. (°F)	Pavement Temp. (°F)	Relative Humidity (%)	Barometric Pressure (mm Hg)
8/8/2012	11:45	79	101	—	29.88
8/8/2012	13:47	79	101	—	29.86
8/8/2012	14:00	77	100	—	29.87
11/21/2016	10:00	67	74	75	30.02
11/21/2016	12:06	66	76	86	29.97
11/21/2016	13:20	68	76	74	29.97
11/21/2016	14:27	66	75	85	29.95

3.8.1 San Diego 5 NB Lane 1 – PM 36.4 – JPCP with GnG

Table 3.59 summarizes the test results for this section.

Table 3.59: Summary of Test Results for San Diego 5 NB Lane 1 – PM 36.4

Date	Average, OBSI (dBA)	Std. Dev., OBSI (dBA)	Average, IRI (in./mi.)	Std. Dev., IRI (in./mi.)
8/8/2012	100.2	0.6	41.2	0.6
11/20/2016	100.9	0.5	40.2	0.7

3.8.2 San Diego 5 NB Lane 2 – PM 36.4 – JPCP with GnG

Table 3.60 summarizes the test results for this section.

Table 3.60: Summary of Test Results for San Diego 5 NB Lane 2 – PM 36.4

Date	Average, OBSI (dBA)	Std. Dev., OBSI (dBA)	Average, IRI (in./mi.)	Std. Dev., IRI (in./mi.)
8/8/2012	100.9	0.3	43.9	0.7
11/20/2016	102.2	0.4	49.4	0.5

3.8.3 San Diego 5 NB Lane 3 – PM 36.4 – JPCP with GnG

Table 3.61 summarizes the test results for this section.

Table 3.61: Summary of Test Results for San Diego 5 NB Lane 3 – PM 36.4

Date	Average, OBSI (dBA)	Std. Dev., OBSI (dBA)	Average, IRI (in./mi.)	Std. Dev., IRI (in./mi.)
8/8/2012	100.7	0.4	37.7	0.4
11/20/2016	102.2	0.4	43.3	0.8

3.8.4 San Diego 5 NB Lane 4 – PM 36.4 – JPCP with GnG

Table 3.62 summarizes the test results for this section.

Table 3.62: Summary of Test Results for San Diego 5 NB Lane 4 – PM 36.4

Date	Average, OBSI (dBA)	Std. Dev., OBSI (dBA)	Average, IRI (in./mi.)	Std. Dev., IRI (in./mi.)
8/8/2012	101.3	0.3	39.1	0.6
11/20/2016	103.6	0.4	50.0	0.4

3.8.5 San Diego 5 NB Lane 5 – PM 36.4 – JPCP with GnG

Table 3.63 summarizes the test results for this section.

Table 3.63: Summary of Test Results for San Diego 5 NB Lane 5 – PM 36.4

Date	Average, OBSI (dBA)	Std. Dev., OBSI (dBA)	Average, IRI (in./mi.)	Std. Dev., IRI (in./mi.)
8/8/2012	101.2	0.3	37.7	1.1
11/20/2016	102.9	0.6	50.6	0.3

3.8.6 San Diego 5 SB Lane 1 – PM 37.3 – JPCP with GnG

Table 3.64 summarizes the test results for this section.

Table 3.64: Summary of Test Results for San Diego 5 SB Lane 1 – PM 37.3

Date	Average, OBSI (dBA)	Std. Dev., OBSI (dBA)	Average, IRI (in./mi.)	Std. Dev., IRI (in./mi.)
8/8/2012	100.4	0.7	37.3	0.9
11/20/2016	101.1	0.6	40.0	0.7

3.8.7 San Diego 5 SB Lane 2 – PM 37.3 – JPCP with GnG

Table 3.65 summarizes the test results for this section.

Table 3.65: Summary of Test Results for San Diego 5 SB Lane 2 – PM 37.3

Date	Average, OBSI (dBA)	Std. Dev., OBSI (dBA)	Average, IRI (in./mi.)	Std. Dev., IRI (in./mi.)
8/8/2012	101.2	0.5	36.1	1.1
11/20/2016	102.6	0.6	44.4	0.8

3.8.8 San Diego 5 SB Lane 3 – PM 37.3 – JPCP with GnG

Table 3.66 summarizes the test results for this section.

Table 3.66: Summary of Test Results for San Diego 5 SB Lane 3 – PM 37.3

Date	Average, OBSI (dBA)	Std. Dev., OBSI (dBA)	Average, IRI (in./mi.)	Std. Dev., IRI (in./mi.)
8/8/2012	101.0	0.3	41.0	0.7
11/20/2016	102.4	0.5	48.7	0.4

3.8.9 San Diego 5 SB Lane 4 – PM 37.3 – JPCP with GnG

Table 3.67 summarizes the test results for this section.

Table 3.67: Summary of Test Results for San Diego 5 SB Lane 4 – PM 37.3

Date	Average, OBSI (dBA)	Std. Dev., OBSI (dBA)	Average, IRI (in./mi.)	Std. Dev., IRI (in./mi.)
8/8/2012	101.5	0.3	38.4	1.2
11/20/2016	102.7	0.5	51.6	1.0

3.8.10 San Diego 5 SB Lane 5 – PM 37.3 – JPCP with GnG

Table 3.68 summarizes the test results for this section.

Table 3.68: Summary of Test Results for San Diego 5 SB Lane 5 – PM 37.3

Date	Average, OBSI (dBA)	Std. Dev., OBSI (dBA)	Average, IRI (in./mi.)	Std. Dev., IRI (in./mi.)
8/8/2012	101.0	0.4	45.1	1.1
11/20/2016	102.5	0.7	60.5	1.8

3.8.11 San Diego 5 NB Lane 1 – PM 35.8/37.4 – JPCP with CDG

Table 3.69 summarizes the test results for this section.

Table 3.69: Summary of Test Results for San Diego 5 NB Lane 1 – PM 35.8

Date	Average, OBSI (dBA)	Std. Dev., OBSI (dBA)	Average, IRI (in./mi.)	Std. Dev., IRI (in./mi.)
8/8/2012	101.9	0.9	57.4	0.4
11/20/2016	102.9	0.5	59.2	1.5

3.8.12 San Diego 5 NB Lane 2 – PM 35.8/37.4 – JPCP with CDG

Table 3.70 summarizes the test results for this section.

Table 3.70: Summary of Test Results for San Diego 5 NB Lane 2 – PM 35.8

Date	Average, OBSI (dBA)	Std. Dev., OBSI (dBA)	Average, IRI (in./mi.)	Std. Dev., IRI (in./mi.)
8/8/2012	102.9	0.8	62.5	2.3
11/20/2016	104.0	0.3	67.1	1.1

3.8.13 San Diego 5 NB Lane 3 – PM 35.8/37.4 – JPCP with CDG

Table 3.71 summarizes the test results for this section.

Table 3.71: Summary of Test Results for San Diego 5 NB Lane 3 – PM 35.8

Date	Average, OBSI (dBA)	Std. Dev., OBSI (dBA)	Average, IRI (in./mi.)	Std. Dev., IRI (in./mi.)
8/8/2012	102.5	1.1	60.6	1.9
11/20/2016	103.7	0.5	63.9	1.1

3.8.14 San Diego 5 NB Lane 4 – PM 35.8/37.4 – JPCP with CDG

Table 3.72 summarizes the test results for this section.

Table 3.72: Summary of Test Results for San Diego 5 NB Lane 4 – PM 35.8

Date	Average, OBSI (dBA)	Std. Dev., OBSI (dBA)	Average, IRI (in./mi.)	Std. Dev., IRI (in./mi.)
8/8/2012	103.7	0.7	57.3	1.8
11/20/2016	105.0	0.4	64.2	1.1

3.8.15 San Diego 5 NB Lane 5 – PM 35.8/37.4 – JPCP with CDG

Table 3.73 summarizes the test results for this section.

Table 3.73: Summary of Test Results for San Diego 5 NB Lane 5 – PM 35.8

Date	Average, OBSI (dBA)	Std. Dev., OBSI (dBA)	Average, IRI (in./mi.)	Std. Dev., IRI (in./mi.)
8/8/2012	103.3	0.6	60.5	0.5
11/20/2016	104.5	0.3	64.4	1.3

3.8.16 San Diego 5 SB Lane 1 – PM 37.9/36.3 – JPCP with CDG

Table 3.74 summarizes the test results for this section.

Table 3.74: Summary of Test Results for San Diego 5 SB Lane 1 – PM 37.9

Date	Average, OBSI (dBA)	Std. Dev., OBSI (dBA)	Average, IRI (in./mi.)	Std. Dev., IRI (in./mi.)
8/8/2012	101.8	1.3	60.5	0.8
11/20/2016	102.5	1.0	60.1	0.5

3.8.17 San Diego 5 SB Lane 2 – PM 37.9/36.3 – JPCP with CDG

Table 3.75 summarizes the test results for this section.

Table 3.75: Summary of Test Results for San Diego 5 SB Lane 2 – PM 37.9

Date	Average, OBSI (dBA)	Std. Dev., OBSI (dBA)	Average, IRI (in./mi.)	Std. Dev., IRI (in./mi.)
8/8/2012	102.8	1.0	57.6	0.4
11/20/2016	103.8	0.7	60.8	0.9

3.8.18 San Diego 5 SB Lane 3 – PM 37.9/36.3 – JPCP with CDG

Table 3.76 summarizes the test results for this section.

Table 3.76: Summary of Test Results for San Diego 5 SB Lane 3 – PM 37.9

Date	Average, OBSI (dBA)	Std. Dev., OBSI (dBA)	Average, IRI (in./mi.)	Std. Dev., IRI (in./mi.)
8/8/2012	102.6	0.9	62.7	0.8
11/20/2016	103.6	0.6	75.0	3.0

3.8.19 San Diego 5 SB Lane 4 – PM 37.9/36.3 – JPCP with CDG

Table 3.77 summarizes the test results for this section.

Table 3.77: Summary of Test Results for San Diego 5 SB Lane 4 – PM 37.9

Date	Average, OBSI (dBA)	Std. Dev., OBSI (dBA)	Average, IRI (in./mi.)	Std. Dev., IRI (in./mi.)
8/8/2012	103.5	0.7	61.3	0.9
11/20/2016	104.7	0.4	70.2	0.7

3.8.20 San Diego 5 SB Lane 5 – PM 37.9/36.3 – JPCP with CDG

Table 3.78 summarizes the test results for this section.

Table 3.78: Summary of Test Results for San Diego 5 SB Lane 5 – PM 37.9

Date	Average, OBSI (dBA)	Std. Dev., OBSI (dBA)	Average, IRI (in./mi.)	Std. Dev., IRI (in./mi.)
8/8/2012	103.5	0.5	56.6	0.5
11/20/2016	104.8	0.5	62.2	0.6

4 ANALYSIS AND DISCUSSION

The results from the two sets of testing are compared and analyzed in this chapter. Section 4.1 compares the earlier (2012 and 2013) and later (2016 and 2017) OBSI values measured on these test sections, and Section 4.2 compares the IRI values. Within each section, data are first reviewed according to pavement and surface type, comparing the CRCP sections to the JPCP sections with CDG and the JPCP sections with GnG. The data are then reviewed with respect to passenger car lanes and truck lanes.

4.1 On-Board Sound Intensity (OBSI) Data

Table 4.1 shows the OBSI data for all the sections, along with the initial section information from Table 2.3. The additional columns include the sampling interval, or the time in years between measurements; the average OBSI values from the two measurements; the difference between the readings; and the corresponding OBSI change rate in dBA/yr. Appendix A presents the longitudinal OBSI profile for each section.

Figure 4.1 presents the two OBSI data points of each section, with different marker types representing the pavement and surface types: diamonds for the CRCP sections, squares for the JPCP with CDG sections, and circles for the JPCP with GnG sections. Figure 4.2 excludes two CRCP sections, Placer 80 and Kern 5, for a better view of the data and displays the center of data for pavement and surface types. Figure 4.3 simply presents the average OBSI values and change rates for pavement types and surfaces.

The 2012/2013 OBSI values range between 100.2 dBA and 111.6 dBA, and the 2016/2017 OBSI values range between 100.9 dBA and 111.6 dbA. Considering all sections, the OBSI change rate averaged 0.3 dBA/yr. and did not exceed 1.0 dBA/yr. on any section. These are within the typical range of OBSI values for concrete pavement surfaces measured in similar studies (*3,10*).

Table 4.1: Average OBSI Values for All Sections

Test Section Location	Length (mi.)	Pavement Type[a]	Surface Texture[b]	Lane Type[c]	Climate Region	Last Retexturing	Sampling Interval (years)	2012/2013 OBSI (dBA)	2016/2017 OBSI (dBA)	OBSI Increase[d] (dBA)	OBSI Change Rate (dBA/yr.)
Pla80E1PM56.45	0.1	CRCP	LT	P	High Mountain	4/1/2012	2.9	106.7	109.1	2.4	0.8
Sis5N2PM57.0	0.1	CRCP	CDG	T	High Desert	9/26/2007	3.6	104.3	105.0	0.7	0.2
Ker5S2PM40.0	0.1	CRCP	LT	T	Inland Valley	8/23/2010	3.9	111.6	111.6	0.0	0.0
SJ5N1PM32.0	0.1	CRCP	CDG	P	Inland Valley	1/26/2017	—	—	103.6	—	—
Imp78E2PMR15.0	0.1	CRCP	LT	T	Desert	1/1/2012	4.3	101.6	101.8	0.2	0.1
Imp86S2PMR24.2	0.1	CRCP	LT	T	Desert	1/2/2012	4.3	104.1	103.6	-0.5	-0.1
Sac5N1PM20.0	1.5	JPCP	GnG	P	Inland Valley	7/1/2011	5.3	102.5	103.5	0.9	0.2
Sac5N4PM20.0	1.5	JPCP	GnG	T	Inland Valley	7/1/2011	5.3	103.0	105.2	2.1	0.4
Sac5S1PM21.5	1.5	JPCP	CDG	P	Inland Valley	7/1/2011	5.3	101.8	103.2	1.4	0.3
Sac5S4PM21.5	1.5	JPCP	CDG	T	Inland Valley	7/1/2011	5.3	103.0	104.9	1.9	0.4
Sac5N1PM1.5	1.5	JPCP	GnG	P	Inland Valley	12/1/2011	5.3	101.7	103.9	2.2	0.4
Sac5N2PM1.5	1.5	JPCP	GnG	T	Inland Valley	12/1/2011	5.2	102.1	105.1	3.0	0.6
Sac5S1PM3.0	1.5	JPCP	CDG	P	Inland Valley	12/1/2011	5.3	103.4	103.9	0.5	0.1
Sac5S2PM3.0	1.5	JPCP	CDG	T	Inland Valley	12/1/2011	5.2	103.6	104.4	0.8	0.2
Sac80E2PM13.0	1.0	JPCP	GnG	P	Inland Valley	5/1/2012	4.4	101.8	103.7	1.9	0.4
Sac80E5PM13.0	1.0	JPCP	GnG	T	Inland Valley	5/1/2012	4.4	101.8	103.0	1.2	0.3
Sac80W2PM14.0	1.0	JPCP	GnG	P	Inland Valley	5/1/2012	4.4	101.7	103.1	1.4	0.3
Sac80W5PM14.0	1.0	JPCP	GnG	T	Inland Valley	5/1/2012	4.4	102.0	102.9	0.9	0.2
Sac50E2PM13.0	1.0	JPCP	CDG	P	Inland Valley	6/1/2012	4.4	103.0	103.9	0.8	0.2
Sac50E4PM13.0	1.0	JPCP	CDG	T	Inland Valley	6/1/2012	4.4	103.0	105.5	2.4	0.5
Sac50W2PM14.0	1.0	JPCP	GnG	P	Inland Valley	6/1/2012	4.4	100.9	102.7	1.8	0.4
Sac50W4PM14.0	1.0	JPCP	GnG	T	Inland Valley	6/1/2012	4.4	101.0	105.6	4.6	1.0
SJ99N1PM29.0	1.7	JPCP	GnG	P	Inland Valley	7/1/2012	4.6	100.7	103.1	2.4	0.5
SJ99N2PM29.0	1.7	JPCP	GnG	T	Inland Valley	7/1/2012	4.6	101.5	104.5	3.0	0.7
Yol113N1PM0.5	1.0	JPCP	GnG	P	Inland Valley	4/1/2012	3.3	100.6	102.0	1.4	0.4
Yol113N2PM0.5	1.0	JPCP	GnG	T	Inland Valley	4/1/2012	3.3	100.4	102.6	2.1	0.6
Yol113S1PM0.9	0.5	JPCP	GnG	P	Inland Valley	4/1/2012	3.3	100.6	102.3	1.7	0.5
Yol113S2PM0.9	0.5	JPCP	GnG	T	Inland Valley	4/1/2012	3.3	100.2	102.1	1.8	0.6
Yol113N1PM1.5	1.0	JPCP	CDG	P	Inland Valley	4/1/2012	3.3	102.3	103.2	0.9	0.3
Yol113N2PM1.5	1.0	JPCP	CDG	T	Inland Valley	4/1/2012	3.3	101.2	103.0	1.7	0.5
Yol113S1PM2.5	1.5	JPCP	CDG	P	Inland Valley	4/1/2012	3.3	101.4	102.2	0.8	0.2
Yol113S2PM2.5	1.5	JPCP	CDG	T	Inland Valley	4/1/2012	3.3	101.6	102.9	1.3	0.4

SD5N1PM36.4	1.0	JPCP	GnG	P	South Coast	7/1/2012	4.3	100.2	100.9	0.6	0.1
SD5N2PM36.4	1.0	JPCP	GnG	P	South Coast	7/1/2012	4.3	100.9	102.2	1.4	0.3
SD5N3PM36.4	1.0	JPCP	GnG	P	South Coast	7/1/2012	4.3	100.7	102.2	1.6	0.4
SD5N4PM36.4	1.0	JPCP	GnG	T	South Coast	7/1/2012	4.3	101.3	103.6	2.2	0.5
SD5N5PM36.4	1.0	JPCP	GnG	T	South Coast	7/1/2012	4.3	101.2	102.9	1.6	0.4
SD5S1PM37.3	1.0	JPCP	GnG	P	South Coast	7/1/2012	4.3	100.4	101.1	0.7	0.2
SD5S2PM37.3	1.0	JPCP	GnG	P	South Coast	7/1/2012	4.3	101.2	102.6	1.4	0.3
SD5S3PM37.3	1.0	JPCP	GnG	P	South Coast	7/1/2012	4.3	101.0	102.4	1.4	0.3
SD5S4PM37.3	1.0	JPCP	GnG	T	South Coast	7/1/2012	4.3	101.5	102.7	1.3	0.3
SD5S5PM37.3	1.0	JPCP	GnG	T	South Coast	7/1/2012	4.3	101.0	102.5	1.5	0.3
SD5N1PM35.8/37.4	1.0	JPCP	CDG	P	South Coast	4/1/2011	4.3	101.9	102.9	0.9	0.2
SD5N2PM35.8/37.4	1.0	JPCP	CDG	P	South Coast	4/1/2011	4.3	102.9	104.0	1.1	0.3
SD5N3PM35.8/37.4	1.0	JPCP	CDG	P	South Coast	4/1/2011	4.3	102.5	103.7	1.2	0.3
SD5N4PM35.8/37.4	1.0	JPCP	CDG	T	South Coast	4/1/2011	4.3	103.7	105.0	1.4	0.3
SD5N5PM35.8/37.4	1.0	JPCP	CDG	T	South Coast	4/1/2011	4.3	103.3	104.5	1.2	0.3
SD5S1PM37.9/36.3	1.0	JPCP	CDG	P	South Coast	4/1/2011	4.3	101.8	102.5	0.7	0.2
SD5S2PM37.9/36.3	1.0	JPCP	CDG	P	South Coast	4/1/2011	4.3	102.8	103.8	1.0	0.2
SD5S3PM37.9/36.3	1.0	JPCP	CDG	P	South Coast	4/1/2011	4.3	102.6	103.6	1.0	0.2
SD5S4PM37.9/36.3	1.0	JPCP	CDG	T	South Coast	4/1/2011	4.3	103.5	104.7	1.2	0.3
SD5S5PM37.9/36.3	1.0	JPCP	CDG	T	South Coast	4/1/2011	4.3	103.5	104.8	1.3	0.3

[a] CRCP is continuously reinforced concrete pavement, and JPCP is jointed plain concrete pavement.

[b] LT is longitudinally tined, CDG is conventional diamond grinding, and GnG is grind and groove.

[c] Lane type is passenger (P) or truck (T).

[d] Apparent errors are due to rounding (i.e., for Sac5N1PM20.0, 103.47 – 102.54 = 0.93).

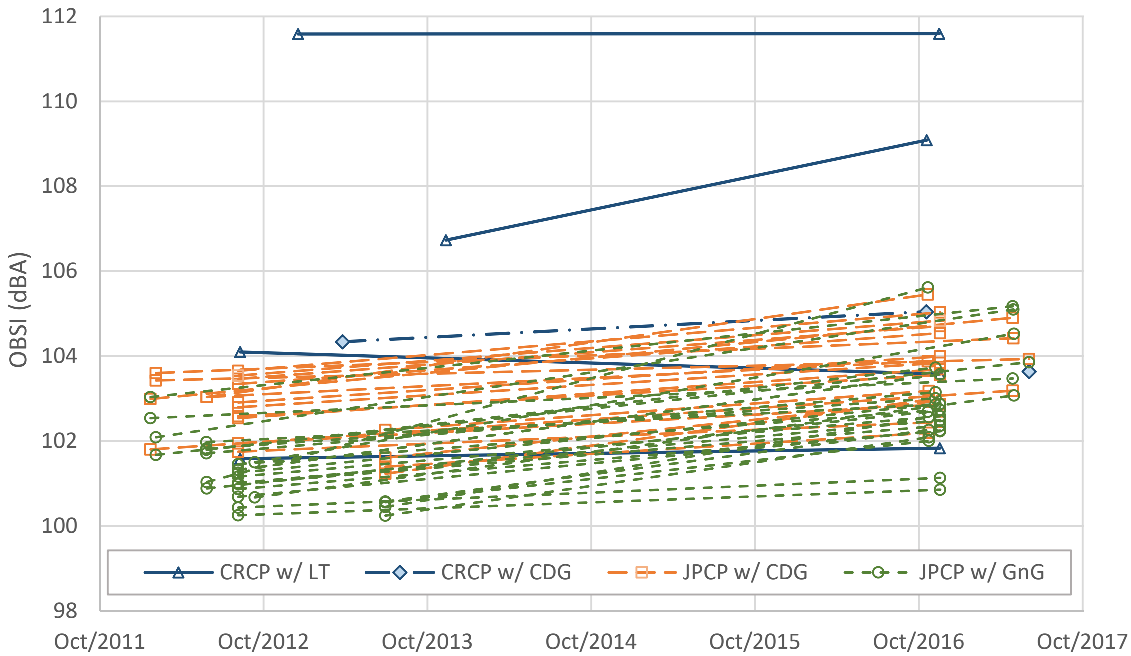


Figure 4.1: OBSI measurements on all sections.

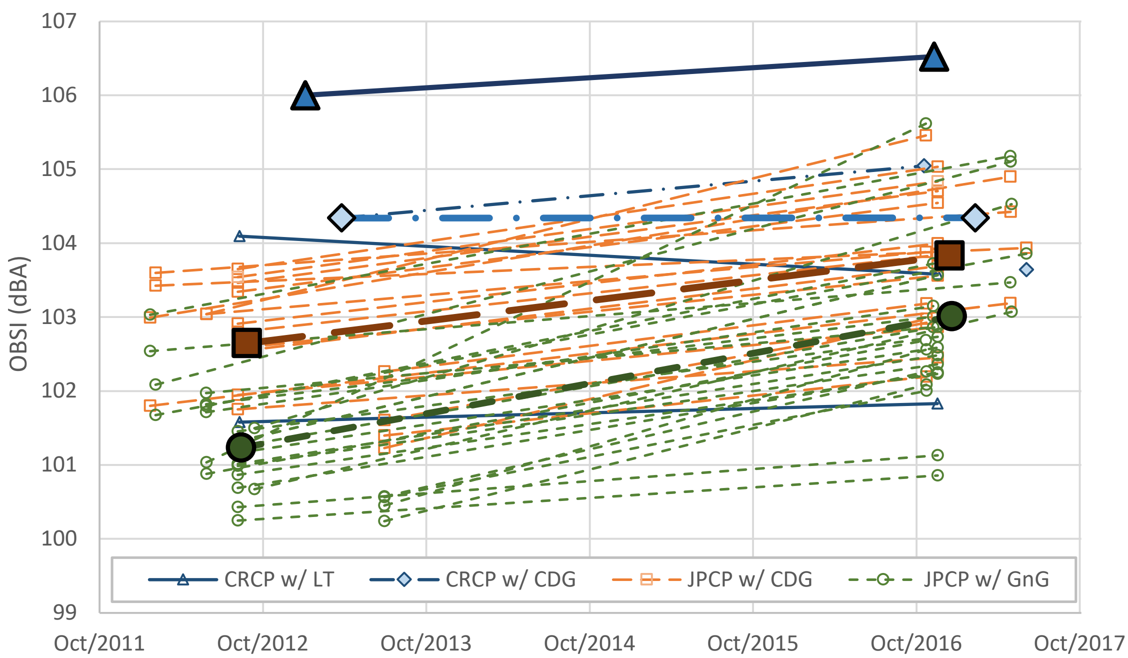


Figure 4.2: OBSI measurements, except Placer 80 and Kern 5, with section type averages.

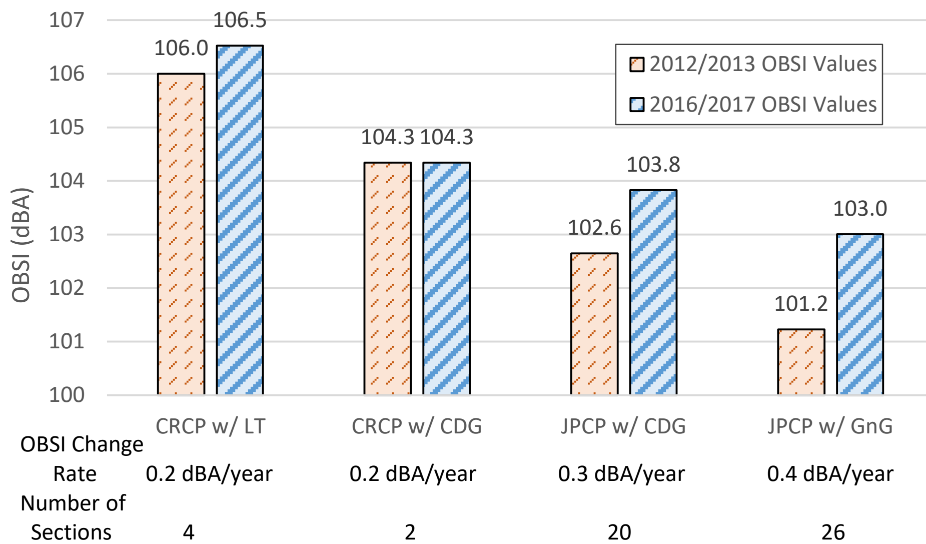


Figure 4.3: Average OBSI values and change rates for pavement types and surfaces.

4.1.1 CRCP Sections

Only five CRCP sections were tested in 2012 and 2013; four were surfaced with LT. Siskiyou 5 was the only CDG-textured section as San Joaquin 5, the other CDG section, was still under construction. Four of the five CRCP sections tested in 2012 and 2013 are the only sections in this study with initial OBSI values over 104 dBA; however, the CRCP sections performed very well. Regardless of the surface texture, the average OBSI change rate was 0.2 dBA/yr.

The averages of all the 2012/2013 and 2016/2017 measurements on the CRCP sections were 105.7 dBA and 105.8 dBA, respectively. Although Kern 5 was the loudest section in both years of measurement, at 111.6 dBA, there was no measured increase in the OBSI. Negligible increases in OBSI were measured on the CRCP sections, except for Placer 80 which showed an increase of 2.4 dBA over almost three years. While Placer 80 did show one of the larger rates of increase, 0.8 dBA/yr., it is located along a major trucking route in the High Mountain climate region where snow chains can be required. Exposure to chain wear may have also affected Siskiyou 5, located in High Desert, which showed the second highest OBSI deterioration rate among the CRCP sections.

Placer 80 and San Joaquin 5, with only one data collection, are the only passenger lanes; however, too little data exists to compare passenger lanes and truck lanes for CRCP sections. Similarly, it is difficult to compare surface textures because of so few sections. San Joaquin 5 is one of two CDG sections, along with Siskiyou 5, while the other four CRCP sections are textured with LT. Figure 4.3 shows that the CRCP with LT sections are the louder sections. However, with only two sections of CRCP with CDG, there is no clear difference between the noise values for the CRCP surface types. Excluding Placer 80 from the other three LT sections drops the average change rate to 0.02 dBA/yr. Clearer trends may become apparent with the next data collections.

4.1.2 JPCP Sections with CDG

Five of the seven GnG pilot projects contain CDG surfaces as controls for comparison; Sacramento 80 and San Joaquin 99 only have the GnG surface. Table 4.2 shows the OBSI values for all the JPCP sections with CDG surface textures as well as the OBSI change rate, split between passenger and truck lanes. Initial values were collected soon after construction and fell within the range of OBSI values from previous studies (*3*).

Table 4.2: OBSI Values for All JPCP with CDG Sections

Test Section Location	Passenger Lanes			Truck Lanes		
	First OBSI (dBA)	Recent OBSI (dBA)	OBSI Change Rate (dBA/yr.)	First OBSI (dBA)	Recent OBSI (dBA)	OBSI Change Rate (dBA/yr.)
Sac5 S1	101.8	103.2	0.3			
Sac5 S4				103.0	104.9	0.4
Sac5B S1	103.4	103.9	0.1			
Sac5B S2				103.6	104.4	0.2
Sac50 E2	103.0	103.9	0.2			
Sac50 E4				103.0	105.5	0.5
Yol113 N1	102.3	103.2	0.3			
Yol113 N2				101.2	103.0	0.5
Yol113 S1	101.4	102.2	0.2			
Yol113 S2				101.6	102.9	0.4
SD5 N1	101.9	102.9	0.2			
SD5 N2	102.9	104.0	0.3			
SD5 N3	102.5	103.7	0.3			
SD5 N4				103.7	105.0	0.3
SD5 N5				103.3	104.5	0.3
SD5 S1	101.8	102.5	0.2			
SD5 S2	102.8	103.8	0.2			
SD5 S3	102.6	103.6	0.2			
SD5 S4				103.5	104.7	0.3
SD5 S5				103.5	104.8	0.3
Average	**102.4**	**103.3**	**0.2**	**102.9**	**104.4**	**0.4**

The average 2012/2013 OBSI values of 102.6 dBA is lower than the average from the Year 1 data of the concrete noise study, 103.8 dBA, and the 2016/2017 average of 103.8 dBA is lower than the Year 4 data from the concrete noise study, 105.5 dBA (*3*). However, the concrete noise study collected data on new and aged surfaces throughout the study, whereas the surfaces in this study are all new.

Inclusion of new and aged surfaces may also explain the difference in the OBSI change rate. The OBSI change rate for CDG surfaces was reported as 0.8 dBA/yr. across the four-year study, much higher than the 0.3 dBA/yr. measured for this study.

Figure 4.4 separates the JPCP with CDG sections between the truck and passenger lanes. Except for two truck lanes, both Yol113N2 and Yol113S2, the OBSI in the JPCP with CDG truck lanes are among the higher values measured in 2012/2013 and in 2016/2017. While it is uncertain why these truck lanes have lower OBSI values, there is much less truck traffic on these sections than other sections in the study. The truck AADT for Yolo 113 remains around 2,000, whereas the Sacramento 5 and San Diego 5 sections have truck AADTs approaching 15,000 and 10,000, respectively. Furthermore, the initial OBSI after the initial readings may be the result of construction quality.

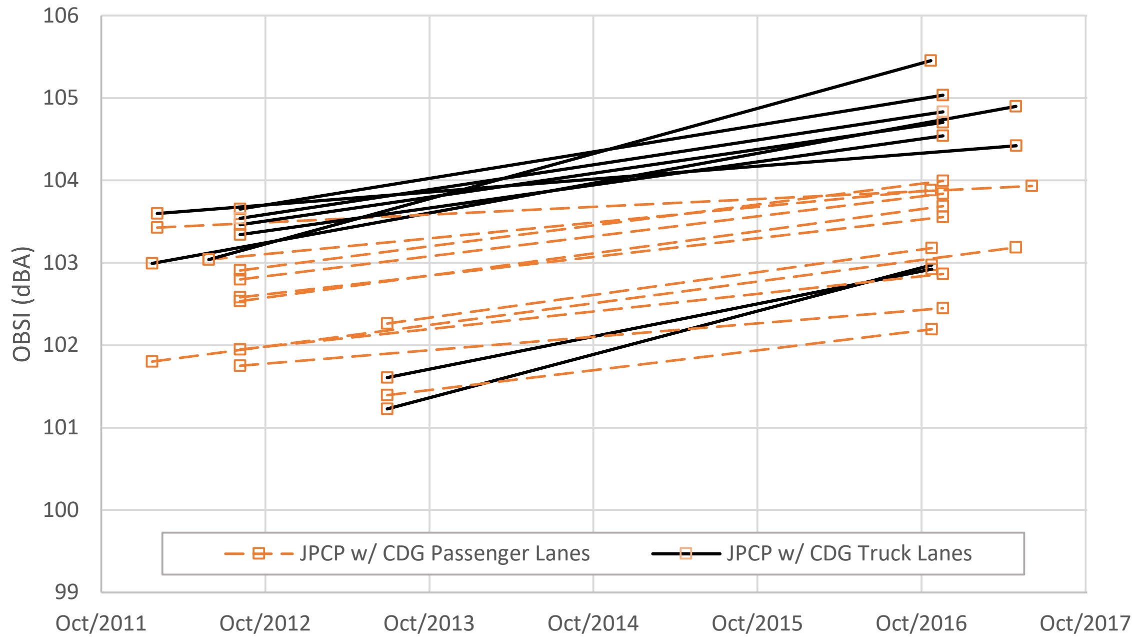


Figure 4.4: OBSI on JPCP with CDG truck and passenger lanes.

Figure 4.5 presents the average OBSI values and change rates for passenger and truck lanes on JPCP with CDG sections. The averages show the truck lanes OBSI change rate is over 50% greater than the change rate in the passenger lanes, 0.22 dBA/yr. and 0.35 dBA/yr., respectively. This may be an indication of the impact of truck traffic on concrete surface texture.

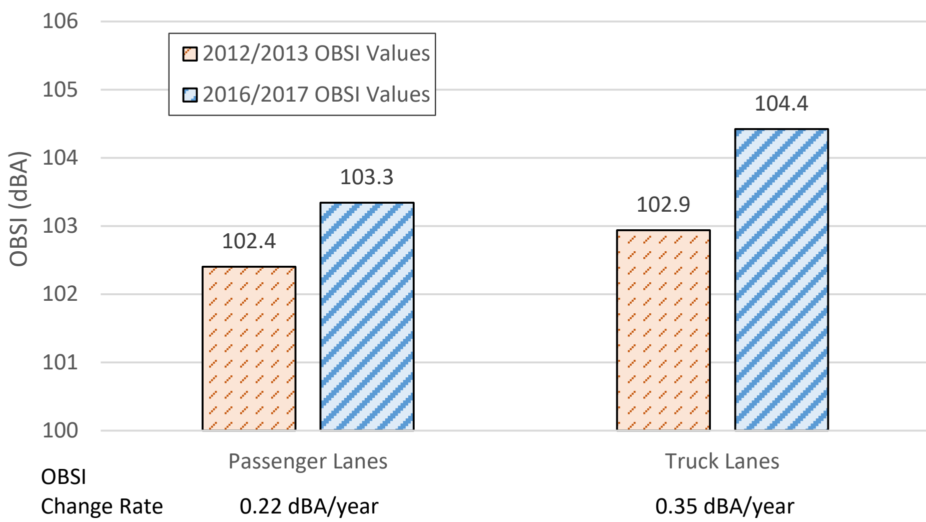


Figure 4.5: Average OBSI and change rates for JPCP with CDG sections, passenger and truck lanes.

4.1.3 JPCP Sections with GnG

Table 4.3: OBSI Values for All JPCP with GnG sections shows the OBSI values for all the JPCP sections with GnG surface textures as well as the OBSI change rate. The 2012/2013 values were collected along with the JPCP sections with CDG, soon after construction. These values also fall within the range of values found outside the state (*4*) and show an average initial OBSI of 101.2 dBA. Like the CDG sections after construction, there is little difference between the passenger and truck lanes of the GnG sections after construction.

The average 2012/2013 OBSI value of the JPCP with GnG sections, 101.2 dBA, is lower than the average from JPCP with CDG sections, 102.6 dBA, and the 2016/2017 average of 103.0 dBA is lower than the average from JPCP with CDG sections, 103.8 dBA. The differences between the averages are less than humans can perceive (*11*). Comparing the OBSI change rates, the change rate for GnG sections is 0.41 dBA/yr. versus 0.28 dBA/yr. for CDG sections.

Figure 4.6 separates the JPCP with GnG sections between the truck and passenger lanes. For the JPCP with GnG sections, the 2012/2013 OBSI values from the passenger and truck lanes are similar, 101.1 dBA and 101.4 dBA, respectively.

Table 4.3: OBSI Values for All JPCP with GnG sections

Test Section Location	Passenger Lanes			Truck Lanes		
	First OBSI (dBA)	Recent OBSI (dBA)	OBSI Change Rate (dBA/yr.)	First OBSI (dBA)	Recent OBSI (dBA)	OBSI Change Rate (dBA/yr.)
Sac5 N1	102.5	103.5	0.2			
Sac5 N4				103.0	105.2	0.4
Sac5B N1	101.7	103.9	0.4			
Sac5B N2				102.1	105.1	0.6
Sac80 E2	101.8	103.7	0.4			
Sac80 E5				101.8	103.0	0.3
Sac80 W2	101.7	103.1	0.3			
Sac80 W5				102.0	102.9	0.2
Sac50 W2	100.9	102.7	0.4			
Sac50 W4				101.0	105.6	1.0
SJ99 N1	100.7	103.1	0.5			
SJ99 N2				101.5	104.5	0.7
Yol113 N1	100.6	102.0	0.4			
Yol113 N2				100.4	102.6	0.6
Yol113 S1	100.6	102.3	0.5			
Yol113 S2				100.2	102.1	0.6
SD5 N1	100.2	100.9	0.1			
SD5 N2	100.9	102.2	0.3			
SD5 N3	100.7	102.2	0.4			
SD5 N4				101.3	103.6	0.5
SD5 N5				101.2	102.9	0.4
SD5 S1	100.4	101.1	0.2			
SD5 S2	101.2	102.6	0.3			
SD5 S3	101.0	102.4	0.3			
SD5 S4				101.5	102.7	0.3
SD5 S5				101.0	102.5	0.3
Average	**101.1**	**102.5**	**0.3**	**101.4**	**103.5**	**0.5**

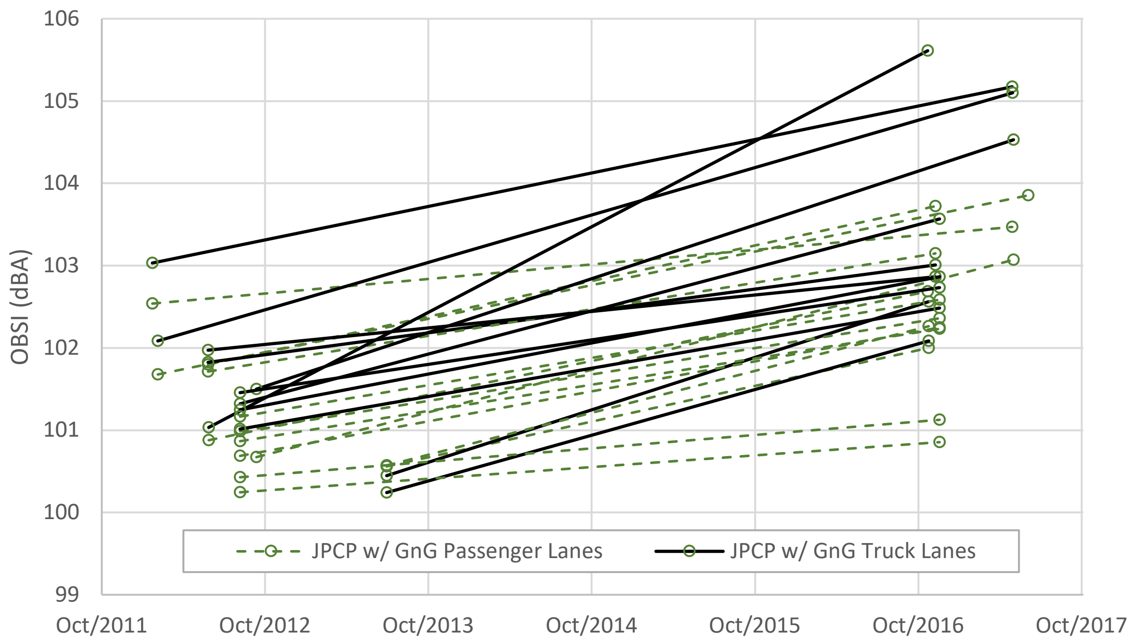


Figure 4.6: OBSI on JPCP with GnG truck and passenger lanes.

Figure 4.7 presents the average OBSI values and change rates for passenger and truck lanes on JPCP with GnG sections. The effect of truck traffic may again be indicated by the difference in OBSI change rates when comparing to the passenger lanes, 0.35 dBA/yr., and to truck lanes, 0.49 dBA/yr. Still, after about four years of traffic, the average OBSI for GnG in the truck lanes is 103.5 dBA compared to 104.4 dBA for the CDG sections in this study. This difference is less than humans can perceive (*11*).

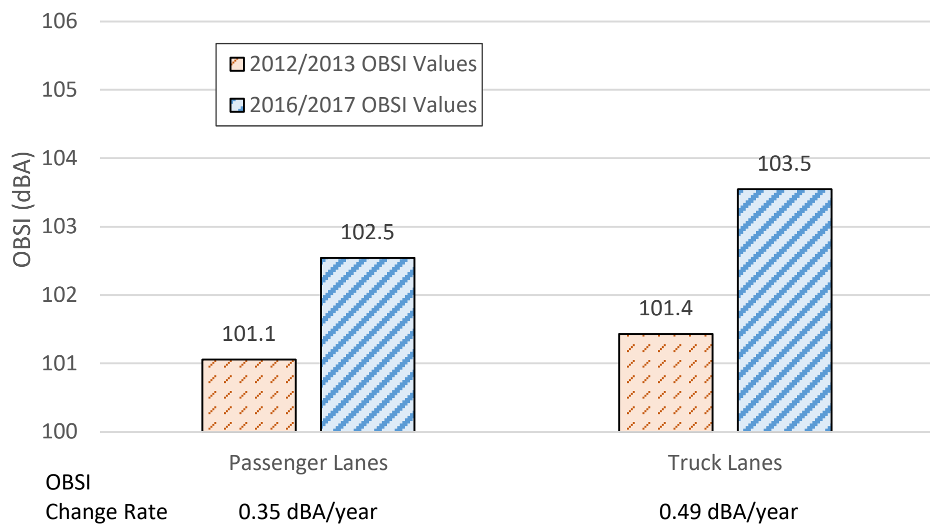


Figure 4.7: Average OBSI and change rates for JPCP with GnG sections, passenger and truck lanes.

4.2 International Roughness Index (IRI) Data

Table 4.4: IRI Values for All Sections shows the IRI data for all sections, along with the initial section information from Table 2.3. The additional columns include the sampling interval, or the time in years between measurements; the average IRI values from the two measurements; the difference between the readings; and the corresponding IRI change rate in in./mi. per year. Appendix B presents the figures of OBSI data for selected sections.

Figure 4.8 presents the two IRI data points of each section, with different marker types representing the pavement and surface types (diamonds for the CRCP sections, squares for the JPCP with CDG sections, and circles for the JPCP with GnG sections), along with the center of data for the section types. Figure 4.9 presents the average IRI values and change rates for pavement types and surfaces.

The 2012/2013 IRI values range between 34 in./mi. and 90 in./mi., and the 2016/2017 IRI values range between 40 in./mi. and 101 in./mi. Only one section, Sac5S4PM21.5, had the 2016/2017 IRI value at or above 95 in./mi. the lower threshold for “acceptable” roughness according to the FHWA (*12*). Almost half the sections, 25 of 52, have a “good” condition rating, with IRI values between 60 in./mi. and 94 in./mi. The remaining sections have IRI values below the construction acceptance standard of 60 in./mi.

Table 4.4: IRI Values for All Sections

Test Section Location	Length (mi.)	Pavement Type[a]	Surface Texture[b]	Lane Type[c]	Climate Region	Last Retexturing	Sampling Interval	2012/2013 IRI (in./mi.)	2016/2017 IRI (in./mi.)	IRI Increase[d] (in./mi.)	IRI Change Rate (in/mi/yr.)
Pla80E1PM56.45	0.1	CRCP	LT	P	High Mountain	4/1/2012	2.9	74	91	16	5.5
Sis5N2PM57.0	0.1	CRCP	CDG	T	High Desert	9/26/2007	3.6	65	50	-15	-4.3
Ker5S2PM40.0	0.1	CRCP	LT	T	Inland Valley	8/23/2010	3.9	90	77	-12	-3.1
SJ5N1PM32.0	0.1	CRCP	CDG	P	Inland Valley	1/26/2017	—	—	64	—	—
Imp78E2PMR15.0	0.1	CRCP	LT	T	Desert	1/1/2012	4.3	54	70	16	3.7
Imp86S2PMR24.2	0.1	CRCP	LT	T	Desert	1/2/2012	4.3	50	51	1	0.2
Sac5N1PM20.0	1.5	JPCP	GnG	P	Inland Valley	7/1/2011	5.3	42	46	4	0.7
Sac5N4PM20.0	1.5	JPCP	GnG	T	Inland Valley	7/1/2011	5.3	52	64	12	2.3
Sac5S1PM21.5	1.5	JPCP	CDG	P	Inland Valley	7/1/2011	5.3	84	79	-5	-1.0
Sac5S4PM21.5	1.5	JPCP	CDG	T	Inland Valley	7/1/2011	5.3	75	101	26	4.9
Sac5N1PM1.5	1.5	JPCP	GnG	P	Inland Valley	12/1/2011	5.3	43	47	4	0.8
Sac5N2PM1.5	1.5	JPCP	GnG	T	Inland Valley	12/1/2011	5.2	48	—	—	—
Sac5S1PM3.0	1.5	JPCP	CDG	P	Inland Valley	12/1/2011	5.3	63	61	-2	-0.4
Sac5S2PM3.0	1.5	JPCP	CDG	T	Inland Valley	12/1/2011	5.2	65	61	-4	-0.8
Sac80E2PM13.0	1.0	JPCP	GnG	P	Inland Valley	5/1/2012	4.4	34	45	11	2.4
Sac80E5PM13.0	1.0	JPCP	GnG	T	Inland Valley	5/1/2012	4.4	42	49	7	1.6
Sac80W2PM14.0	1.0	JPCP	GnG	P	Inland Valley	5/1/2012	4.4	42	46	4	0.9
Sac80W5PM14.0	1.0	JPCP	GnG	T	Inland Valley	5/1/2012	4.4	48	66	19	4.2
Sac50E2PM13.0	1.0	JPCP	CDG	P	Inland Valley	6/1/2012	4.4	77	78	1	0.2
Sac50E4PM13.0	1.0	JPCP	CDG	T	Inland Valley	6/1/2012	4.4	77	70	-8	-1.7
Sac50W2PM14.0	1.0	JPCP	GnG	P	Inland Valley	6/1/2012	4.4	63	62	-1	-0.1
Sac50W4PM14.0	1.0	JPCP	GnG	T	Inland Valley	6/1/2012	4.4	52	81	29	6.6
SJ99N1PM29.0	1.7	JPCP	GnG	P	Inland Valley	7/1/2012	4.6	44	46	1	0.3
SJ99N2PM29.0	1.7	JPCP	GnG	T	Inland Valley	7/1/2012	4.6	73	83	10	2.2
Yol113N1PM0.5	1.0	JPCP	GnG	P	Inland Valley	4/1/2012	3.3	53	49	-4	-1.3
Yol113N2PM0.5	1.0	JPCP	GnG	T	Inland Valley	4/1/2012	3.3	48	52	5	1.4
Yol113S1PM0.9	0.5	JPCP	GnG	P	Inland Valley	4/1/2012	3.3	49	56	6	1.8
Yol113S2PM0.9	0.5	JPCP	GnG	T	Inland Valley	4/1/2012	3.3	54	52	-2	-0.5
Yol113N1PM1.5	1.0	JPCP	CDG	P	Inland Valley	4/1/2012	3.3	50	47	-4	-1.1
Yol113N2PM1.5	1.0	JPCP	CDG	T	Inland Valley	4/1/2012	3.3	47	55	8	2.4
Yol113S1PM2.5	1.5	JPCP	CDG	P	Inland Valley	4/1/2012	3.3	55	53	-2	-0.7
Yol113S2PM2.5	1.5	JPCP	CDG	T	Inland Valley	4/1/2012	3.3	68	75	7	2.0

SD5N1PM36.4	1.0	JPCP	GnG	P	South Coast	7/1/2012	4.3	41	40	-1	-0.2
SD5N2PM36.4	1.0	JPCP	GnG	P	South Coast	7/1/2012	4.3	44	49	6	1.3
SD5N3PM36.4	1.0	JPCP	GnG	P	South Coast	7/1/2012	4.3	38	43	6	1.3
SD5N4PM36.4	1.0	JPCP	GnG	T	South Coast	7/1/2012	4.3	39	50	11	2.5
SD5N5PM36.4	1.0	JPCP	GnG	T	South Coast	7/1/2012	4.3	38	51	13	3.0
SD5S1PM37.3	1.0	JPCP	GnG	P	South Coast	7/1/2012	4.3	37	40	3	0.6
SD5S2PM37.3	1.0	JPCP	GnG	P	South Coast	7/1/2012	4.3	36	44	8	1.9
SD5S3PM37.3	1.0	JPCP	GnG	P	South Coast	7/1/2012	4.3	41	49	8	1.8
SD5S4PM37.3	1.0	JPCP	GnG	T	South Coast	7/1/2012	4.3	38	52	13	3.1
SD5S5PM37.3	1.0	JPCP	GnG	T	South Coast	7/1/2012	4.3	45	61	15	3.6
SD5N1PM35.8/37.4	1.0	JPCP	CDG	P	South Coast	4/1/2011	4.3	57	59	2	0.4
SD5N2PM35.8/37.4	1.0	JPCP	CDG	P	South Coast	4/1/2011	4.3	63	67	5	1.1
SD5N3PM35.8/37.4	1.0	JPCP	CDG	P	South Coast	4/1/2011	4.3	61	64	3	0.8
SD5N4PM35.8/37.4	1.0	JPCP	CDG	T	South Coast	4/1/2011	4.3	57	64	7	1.6
SD5N5PM35.8/37.4	1.0	JPCP	CDG	T	South Coast	4/1/2011	4.3	61	64	4	0.9
SD5S1PM37.9/36.3	1.0	JPCP	CDG	P	South Coast	4/1/2011	4.3	61	60	0	-0.1
SD5S2PM37.9/36.3	1.0	JPCP	CDG	P	South Coast	4/1/2011	4.3	58	61	3	0.7
SD5S3PM37.9/36.3	1.0	JPCP	CDG	P	South Coast	4/1/2011	4.3	63	75	12	2.9
SD5S4PM37.9/36.3	1.0	JPCP	CDG	T	South Coast	4/1/2011	4.3	61	70	9	2.1
SD5S5PM37.9/36.3	1.0	JPCP	CDG	T	South Coast	4/1/2011	4.3	57	62	6	1.3

[a] CRCP is continuously reinforced concrete pavement, and JPCP is jointed plain concrete pavement.

[b] LT is longitudinally tined, CDG is conventional diamond grinding, and GnG is grind and groove.

[c] Lane Type is Passenger (P) or Truck (T).

[d] Apparent errors are due to rounding (i.e., for Pla80E1PM56.45, 90.5 – 74.3 = 16.2)

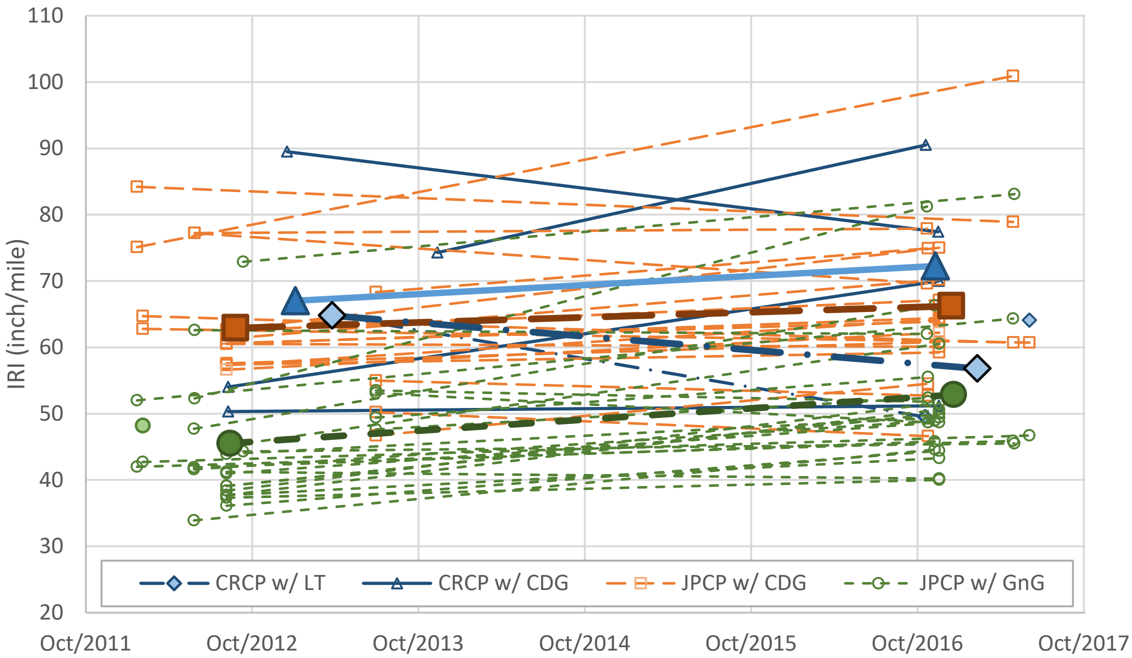


Figure 4.8: IRI measurements with section type averages.

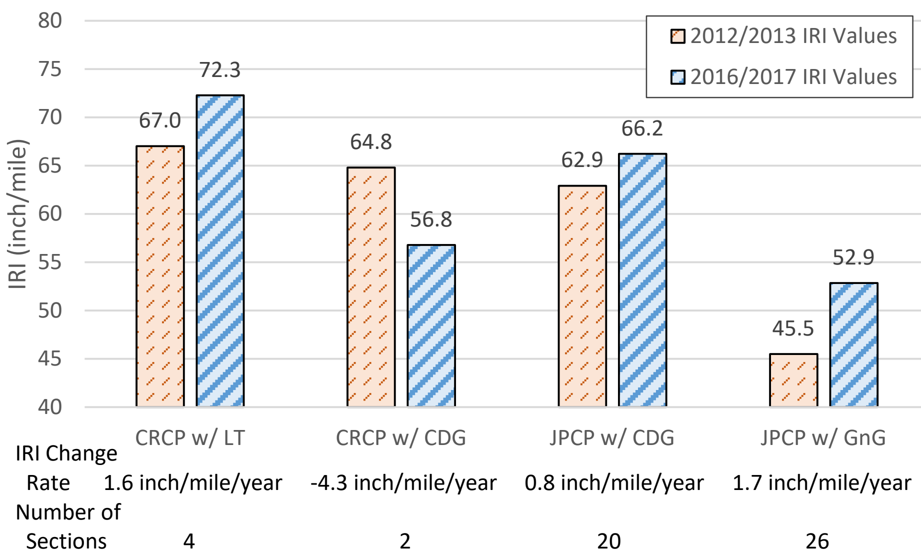


Figure 4.9: Average IRI values for pavement types and surfaces.

It is known that concrete pavement roughness can vary depending on the time of day and season because of thermal gradients causing changes in the slab shape. While environmental conditions were recorded—including the time of day, air temperature, and pavement surface temperature—temperature gradients, which may affect daily and seasonal curling, were not considered in this report. The effects of pavement temperature will be reviewed in the next round of testing and analysis.

4.2.1 CRCP Sections

In terms of smoothness, the CRCP sections performed well. Only two of the six sections, both with LT surface textures, Placer 80 and Imperial 78, showed an increase, both with a change of 16 in./mi. between measurements; an increase of 1 in./mi. on Imperial 86 is considered insignificant.

A decrease in the IRI was measured in two sections, Siskiyou 5 and Kern 5, of 15 in./mi. and 12 in./mi., respectively. The initial IRI measurements collected on these two sections coincided with the coldest air temperature measured in this study, 48°F, and coldest pavement temperature, 54°F. The higher initial IRI measurement relative to the second measurement may be the effect of curling.

Because San Joaquin 5 and Siskiyou 5 are the only CRCP sections with CDG texture and San Joaquin 5 has no 2012 IRI reading, the higher initial IRI measurement on Siskiyou 5 produces a negative IRI deterioration rate, the result of too few data. In this study, the effect of truck chain wear is not evident from these IRI measurements, with Placer 80 showing the largest increase and Siskiyou 5 showing the largest decrease. Otherwise, there are no correlations between the surface texture of these sections and the IRI results.

4.2.2 JPCP Sections with CDG

Table 4.5 shows the IRI values for all the JPCP sections with CDG surface textures as well as the IRI change rate, split between passenger and truck lanes. The average initial and recent IRI values of 63 in./mi. and 66 in./mi. shows that the pavement surfaces start in very good condition. This also corresponds to values from the concrete noise study, where CDG surfaces measured 68 in./mi. (*3*).

Table 4.5: IRI Values for All JPCP with CDG Sections

Test Section Location	Passenger Lanes			Truck Lanes		
	First IRI (in./mi.)	Recent IRI (in./mi.)	IRI Change Rate (in./mi./yr.)	First IRI (in./mi.)	Recent IRI (in./mi.)	IRI Change Rate (in./mi./yr.)
Sac5 S1	84	79	-1.0			
Sac5 S4				75	101	4.9
Sac5B S1	63	61	-0.4			
Sac5B S2				65	61	-0.8
Sac50 E2	77	78	0.2			
Sac50 E4				77	70	-1.7
Yol113 N1	50	47	-1.1			
Yol113 N2				47	55	2.4
Yol113 S1	55	53	-0.7			
Yol113 S2				68	75	2.0
SD5 N1	57	59	0.4			
SD5 N2	63	67	1.1			
SD5 N3	61	64	0.8			
SD5 N4				57	64	1.6
SD5 N5				61	64	0.9
SD5 S1	61	60	-0.1			
SD5 S2	58	61	0.7			
SD5 S3	63	75	2.9			
SD5 S4				61	70	2.1
SD5 S5				57	62	1.3
Average	**63**	**64**	**0.3**	**63**	**69**	**1.4**

The table is split between passenger lanes and the truck lanes, as is the data shown in Figure 4.10, and the average values presented again in Figure 4.11. The averages show both passenger lanes and truck lanes start with an average IRI of 63 in./mi. After a few years, the passenger lanes show little loss of smoothness and the truck lanes (though still in good condition after about four years) lose smoothness at a quicker rate, 1.4 in./mi./yr. for truck lanes versus 0.3 in./mi./yr. for passenger lanes. This may be an indication of the impact of truck traffic on concrete smoothness.

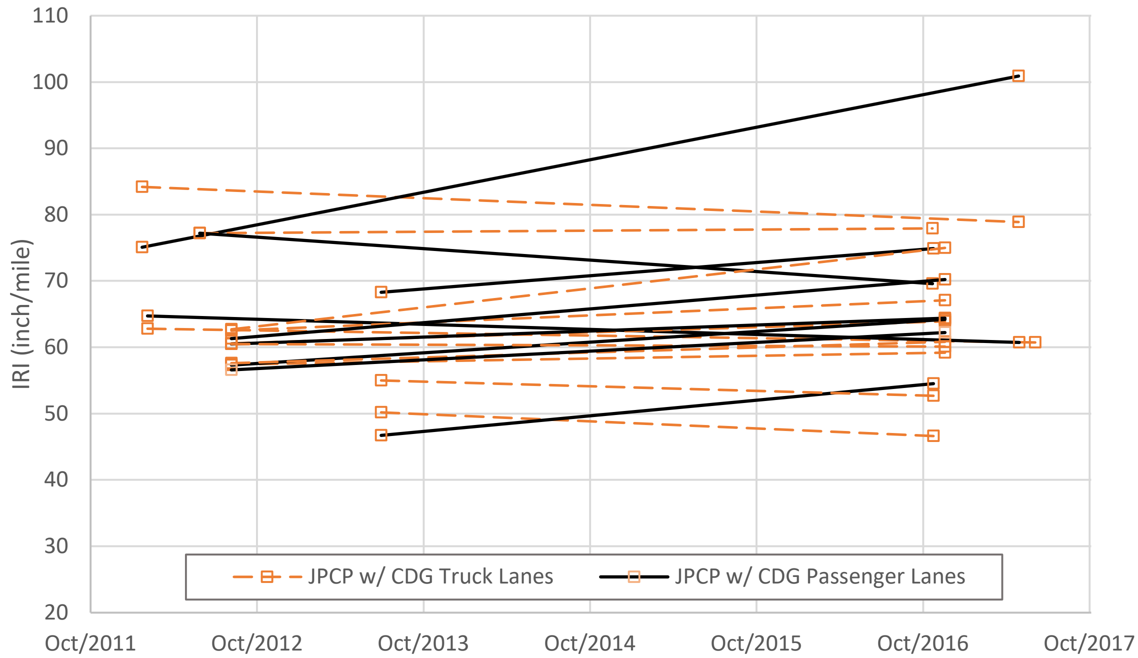


Figure 4.10: IRI on JPCP with CDG truck and passenger lanes.

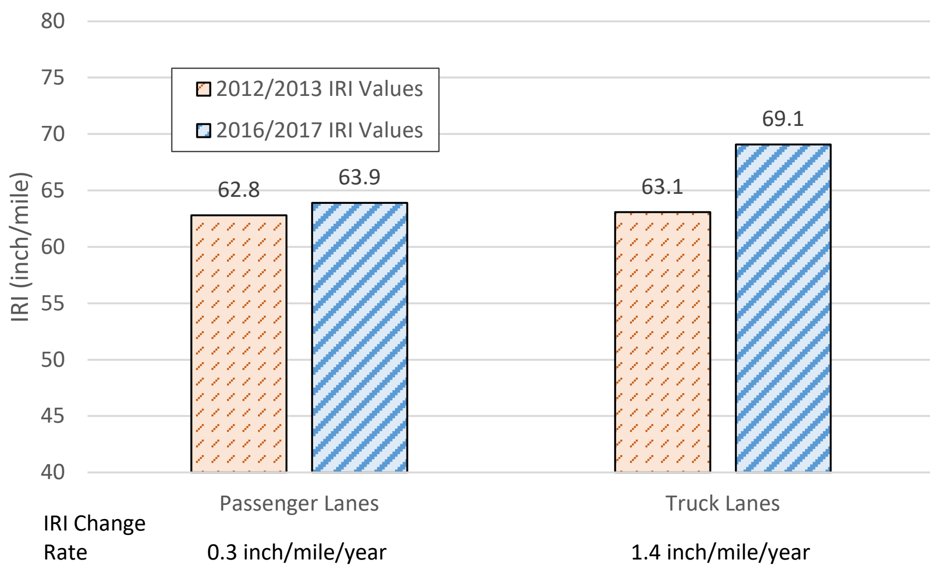


Figure 4.11: Average IRI and change rates for JPCP with CDG sections, passenger and truck lanes.

4.2.3 JPCP Sections with GnG

Table 4.6 shows the IRI values for all the JPCP sections with GnG surface textures as well as the IRI change rate. Overall, these values show the GnG sections start in very good condition in terms of smoothness, and after about four years of traffic, the average IRI for GnG in the truck lanes is only 60 in./mi. compared to 69 in./mi. for the CDG sections in this study.

Table 4.6: IRI Values for All JPCP with GnG Sections

Test Section Location	Passenger Lanes			Truck Lanes		
	First IRI (in./mi.)	Recent IRI (in./mi.)	IRI Change Rate (in./mi./yr.)	First IRI (in./mi.)	Recent IRI (in./mi.)	IRI Change Rate (in./mi./yr.)
Sac5 N1	42	46	0.7			
Sac5 N4				52	64	2.3
Sac5B N1	43	47	0.8			
Sac5B N2				48	—[a]	—[a]
Sac80 E2	34	45	2.4			
Sac80 E5				42	49	1.6
Sac80 W2	42	46	0.9			
Sac80 W5				48	66	4.2
Sac50 W2	63	62	-0.1			
Sac50 W4				52	81	6.6
SJ99 N1	44	46	0.3			
SJ99 N2				73	83	2.2
Yol113 N1	53	49	-1.3			
Yol113 N2				48	52	1.4
Yol113 S1	49	56	1.8			
Yol113 S2				54	52	-0.5
SD5 N1	41	40	-0.2			
SD5 N2	44	49	1.3			
SD5 N3	38	43	1.3			
SD5 N4				39	50	2.5
SD5 N5				38	51	3.0
SD5 S1	37	40	0.6			
SD5 S2	36	44	1.9			
SD5 S3	41	49	1.8			
SD5 S4				38	52	3.1
SD5 S5				45	61	3.6
Average	**43**	**47**	**0.9**	**48**	**60**	**2.7**

[a] No data collected.

Again, the table is split between passenger lanes and truck lanes, as are the data shown in Figure 4.12, and the average values presented in Figure 4.13. Passenger lanes and truck lanes start with average IRI values of 43 in./mi. and 48 in./mi., respectively. These are significantly lower than JPCP with CDG sections with 63 in./mi. for both passenger and truck lanes. After a few years, the JPCP with GnG passenger lanes show some loss of smoothness, increasing the IRI to 47 in./mi., and the truck lanes (though still in good condition after about four years) increase to 60 in./mi.

The IRI change rate for JPCP with GnG sections is the highest when compared to the JPCP with CDG sections and CRCP sections, 1.7 in./mi./yr. versus 0.8 in./mi./yr. and 0.4 in./mi./yr., respectively. Again, truck lanes lose smoothness at a quicker rate, 2.7 in./mi./yr. for truck lanes versus 0.9 in./mi./yr. for passenger lanes. This may be an indication of the impact of truck traffic on concrete smoothness. Looking at both the GnG and CDG change rates for IRI, the truck rate is at least three times larger than the passenger rate.

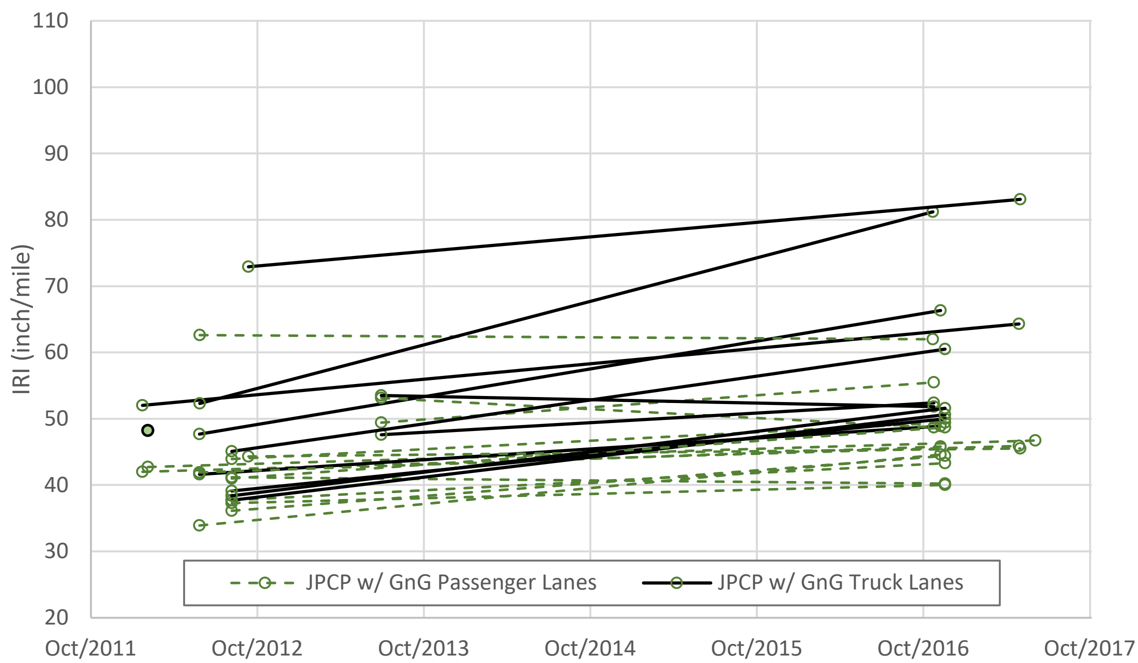


Figure 4.12: IRI on JPCP with GnG truck and passenger lanes.

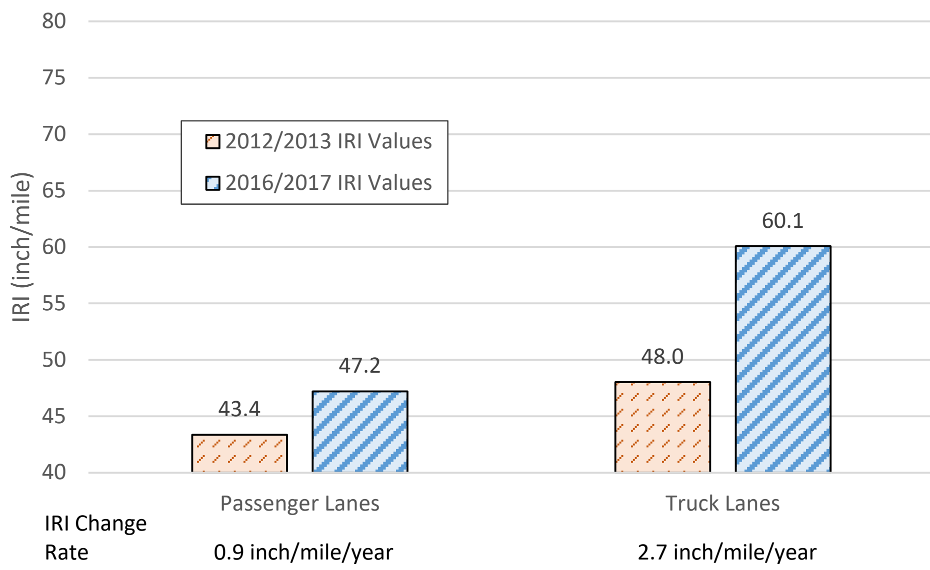


Figure 4.13: Average IRI and change rates for JPCP with GnG sections, passenger and truck lanes.

5 PRELIMINARY CONCLUSIONS AND RECOMMENDATIONS

The results presented in this technical memorandum show two years of measurements of tire/pavement noise in terms of OBSI and smoothness in terms of the IRI on three concrete pavement types relatively new to California: (1) CRCP textured primarily with LT, (2) JPCP textured with CDG, and (3) JPCP textured with the GnG surface. The following are preliminary conclusions regarding tire-pavement noise, OBSI, and pavement smoothness, IRI, from the two sets of data collected about four years apart:

1. OBSI levels on the concrete pavements evaluated in this study originally ranged from 100 dBA to 116 dBA. The data from four years later ranged from 101 dBA to 116 dBA. This is consistent with the range of OBSI levels for concrete pavement textures measured in other similar studies.
2. Among the four pavement types and textures, the CRCP with LT sections on average were the loudest, at 106 dBA. The CRCP with CDG sections on average (with two sections) were the next loudest, at 104 dBA. The CRCP sections overall also showed the lowest rate of change, at 0.2 dBA/yr.; excluding the Placer 80 section, which is affected by truck chain wear, the LT sections rate of change is 0.02 dBA/yr.
3. The OBSI values for the JPCP sections with CDG ranged from 101 dBA to 105 dBA and averaged 103 dBA. The OBSI change rate for the CDG sections averaged 0.3 dBA/yr. These values are within the range of values found in previous studies and are consistent with new and slightly aged diamond ground textures.
4. The OBSI values for the JPCP sections with GnG ranged from 100 dBA to 106 dBA and averaged 102 dBA. On average, the GnG sections were the quietest pavements in this study; however, GnG sections also had the highest OBSI change rate, at 0.4 dBA/yr.
5. The effect of truck traffic versus passenger car traffic on the OBSI change rate is indicated by the JPCP data, excluding the CRCP data. For CDG sections, trucks increase the OBSI change rate from 0.2 dBA/yr. to 0.4 dBA/yr. compared to passenger car lanes, and for the GnG sections, trucks increase the OBSI change rate from 0.3 dBA/yr. to 0.5 dBA/yr.

6. IRI levels on the concrete pavements evaluated in this study originally ranged from 34 in./mi. to 90 in./mi. The data from four years later ranged from 40 in./mi. to 101 in./mi. Only one section, a JPCP section with CDG, deteriorated to the acceptable range of IRI values (95 in./mi. to 170 in./mi.); all other sections remain in good or better condition.
7. Among the three pavement types, the six CRCP sections on average were the roughest, at 67 in./mi. The six CRCP sections also showed the lowest rate of change, at 0.4 in./mi./yr. Separating by surface texture, the one CRCP with CDG section with both data sets showed a decrease in IRI of 15 in./mi.
8. The IRI values for the JPCP sections with CDG ranged from 47 in./mi. to 101 in./mi., with an average of 65 in./mi. The IRI change rate for the CDG sections averaged 0.8 in./mi./yr.
9. The IRI values for the JPCP sections with GnG ranged from 34 in./mi. to 83 in./mi. and averaged 49 in./mi. On average, the GnG sections were the smoothest sections in this study; however, GnG sections also had the highest IRI change rate, at 1.7 in./mi./yr.
10. The effect of truck traffic versus passenger car traffic on the IRI change rate is indicated by the JPCP data. For CDG sections, trucks increase the OBSI change rate from 0.3 in./mi./yr. to 1.4 in./mi./yr., and for the GnG sections, trucks increase the OBSI change rate from 0.9 in./mi./yr. to 2.7 in./mi./yr.

Regarding development and implementation of quieter concrete pavement strategies in California, the results to date in this study suggest the following preliminary recommendations:

1. Continue the use of CDG.
2. Continue the study and use of GnG, specifically looking into long-term performance.
3. Consider using the GnG surface texture on CRCP pavement sections.

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APPENDIX A OBSI LONGITUDINAL PROFILES

Longitudinal profiles of OBSI for all the sections are presented in the following figures. Each profile is an individual lane, with a direction and lane number indicated in the figure header. The figure legend provides the month and year of the two sampling periods, as some project data were collected over multiple days.

After the CRCP profiles in Section A.1, the JPCP profiles were paired by direction for each project in Section A.2 through Section A.8. For example, the Sac 5 – PM 20.0/21.5 charts for northbound Lane 1 and northbound Lane 4 are paired on the same page and southbound Lane 1 and southbound Lane 4 are paired on the following page of Section A.2. With different lanes in the same direction paired, the effect of truck traffic versus passenger car traffic may be evident.

The average OBSI value and standard deviation OBSI values (in parentheses) for the longitudinal profiles are shown under the legend.

The following notation are used in the following figures:

- Empty markers represent the older data.
- Filled markers represent the newer data.
- When there are three lines in a single figure, the empty marker is the oldest data, the lightly filled marker is an intermediate date, and the darker filled marker is the most recent data.

The section location is found in the figure caption, indicating the county and highway number, followed by the direction and lane number, concluding with the starting post mile (PM). For example, Imp86S2PMR24.2 is located in Imperial County on highway 86 in the southbound direction of Lane 2, starting at PM R24.2.

A.1 CRCP Pavement Sections

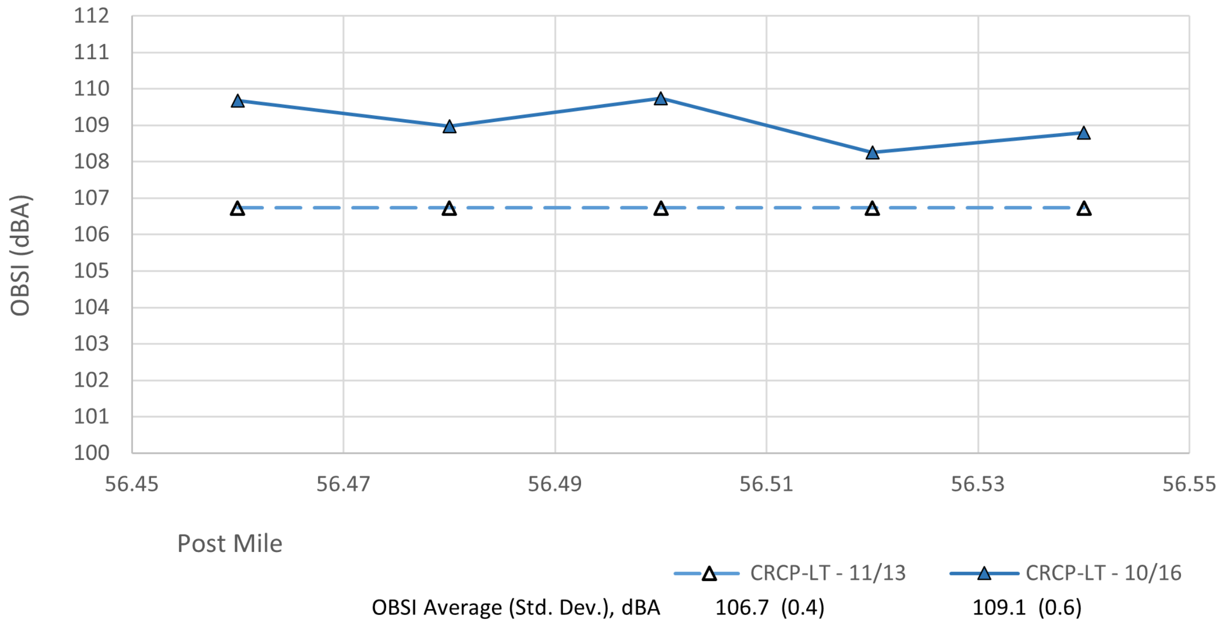

Figure A.1: Pla80E1PM56.45 OBSI data.

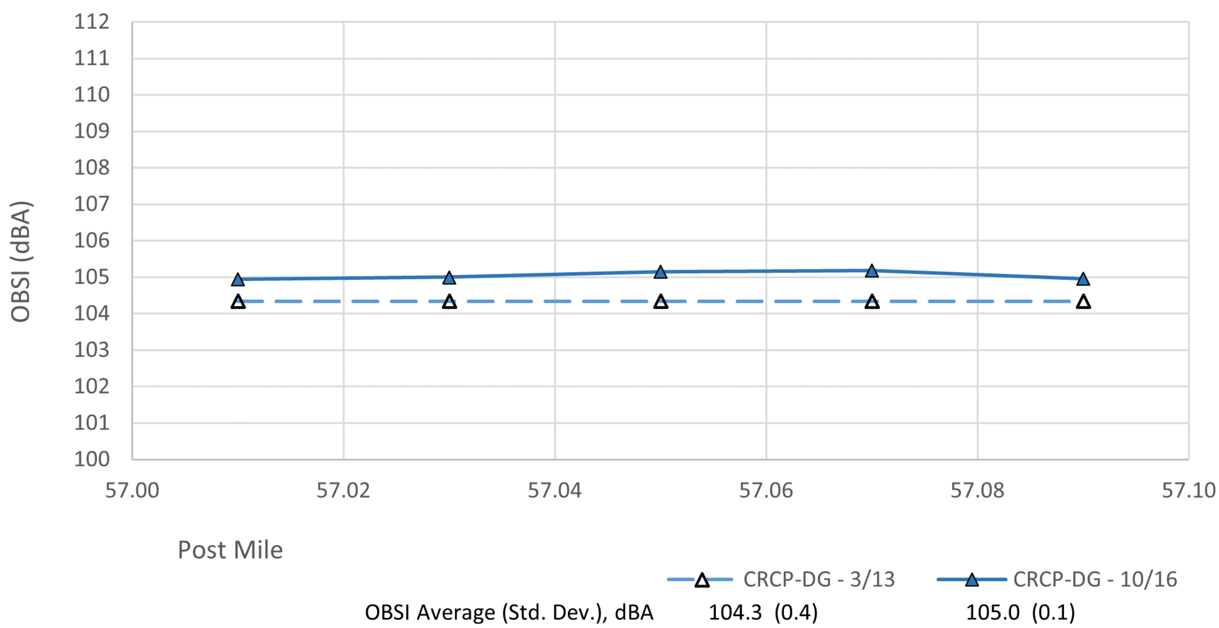

Figure A.2: Sis5N2PM57.0 OBSI data.

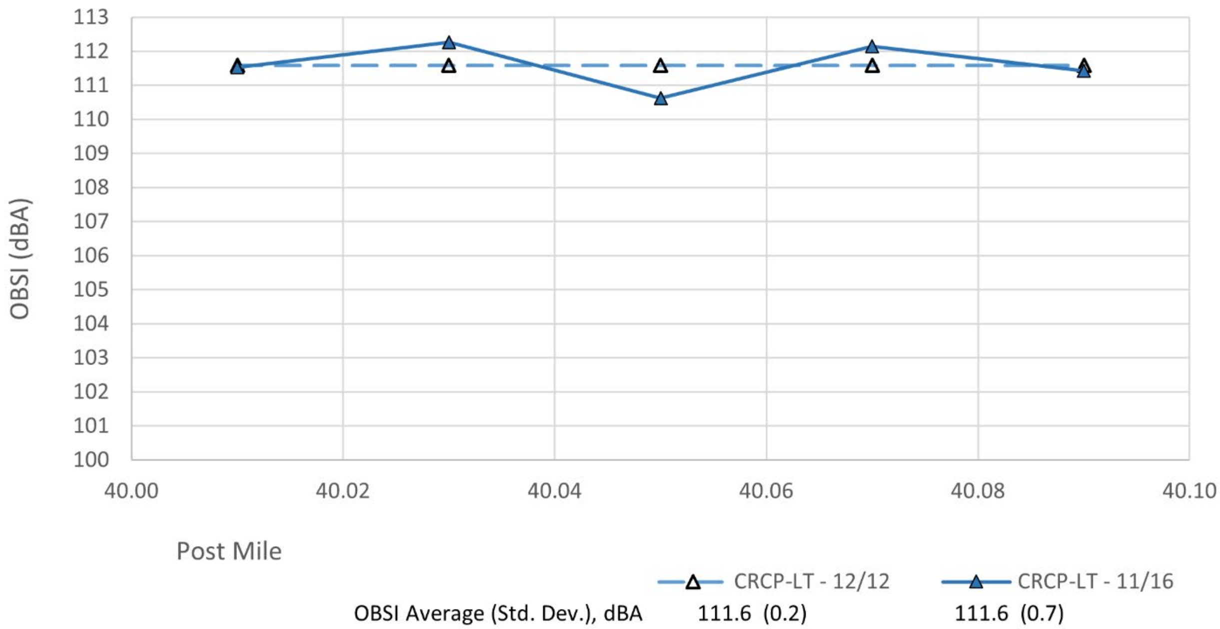

Figure A.3: Ker5S2PM40.0 OBSI data.

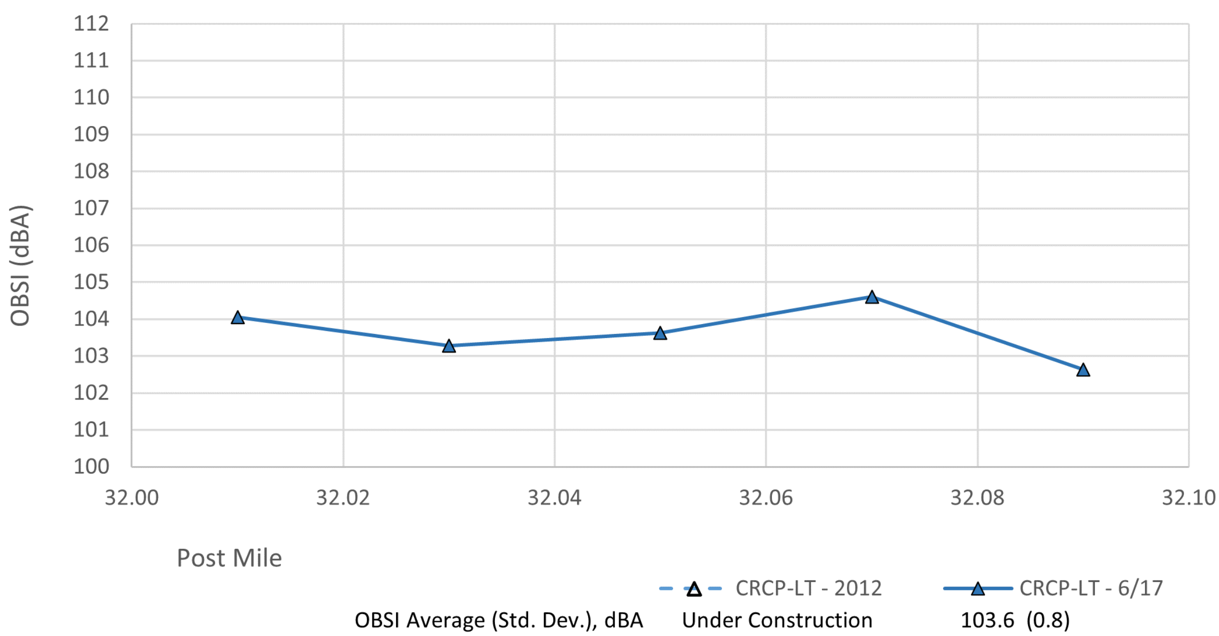

Figure A.4: SJ5N1PM32.0 OBSI data.

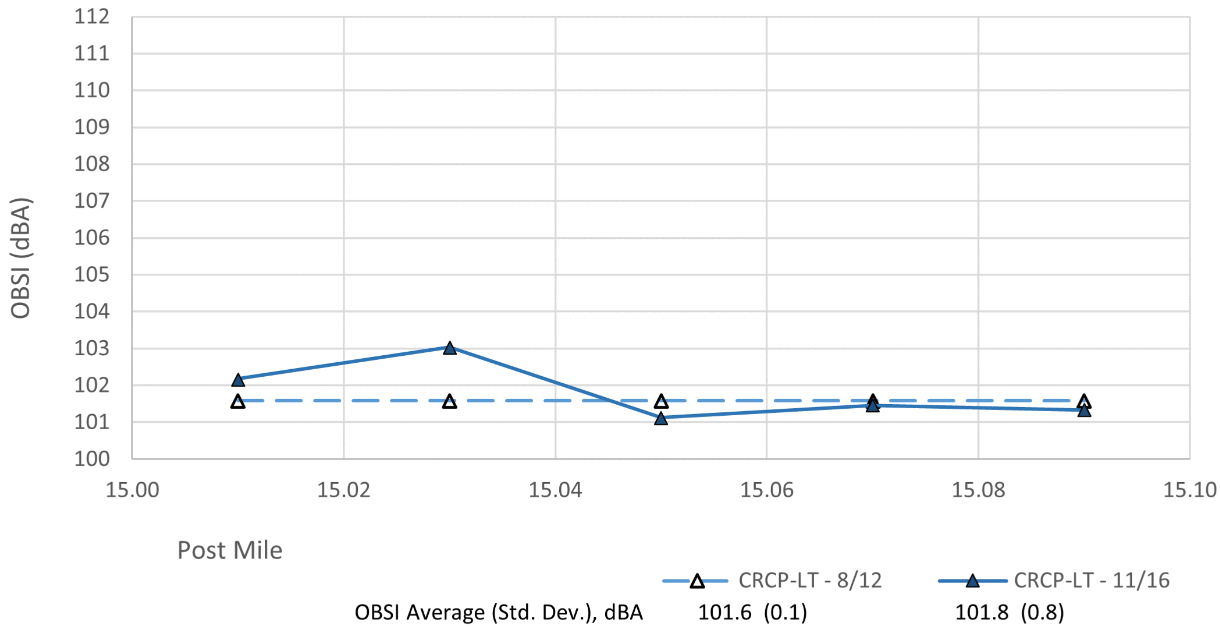

Figure A.5: Imp78E2PMR15.0 OBSI data.

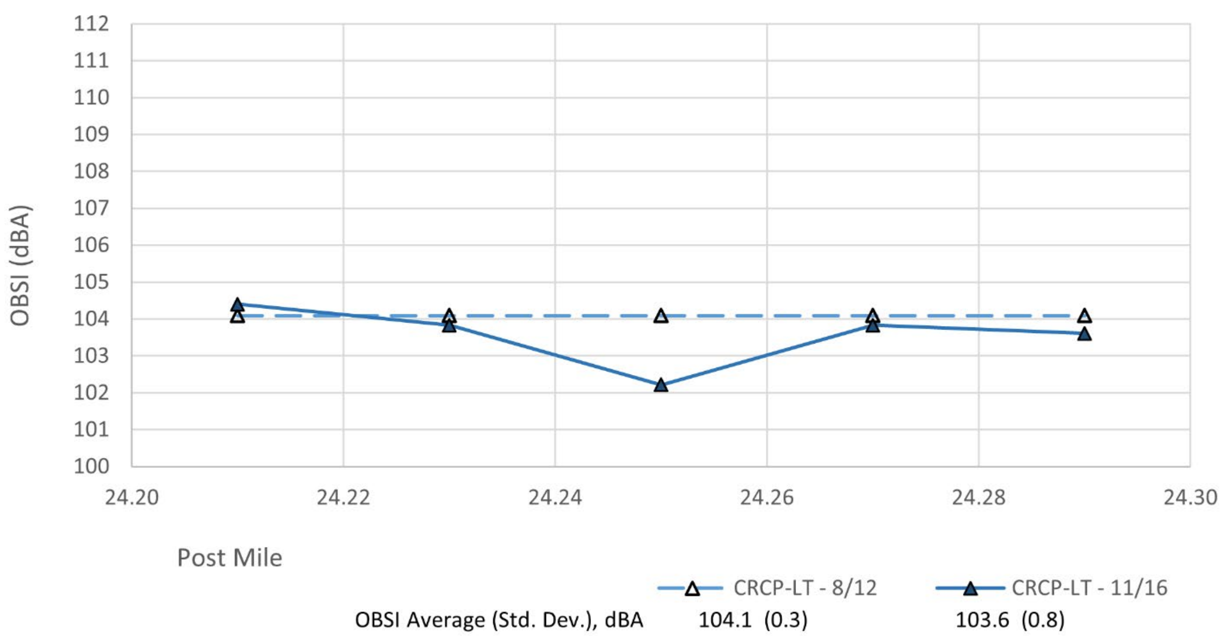

Figure A.6: Imp86S2PMR24.2 OBSI data.

A.2 Sacramento 5 – PM 20.0/21.5

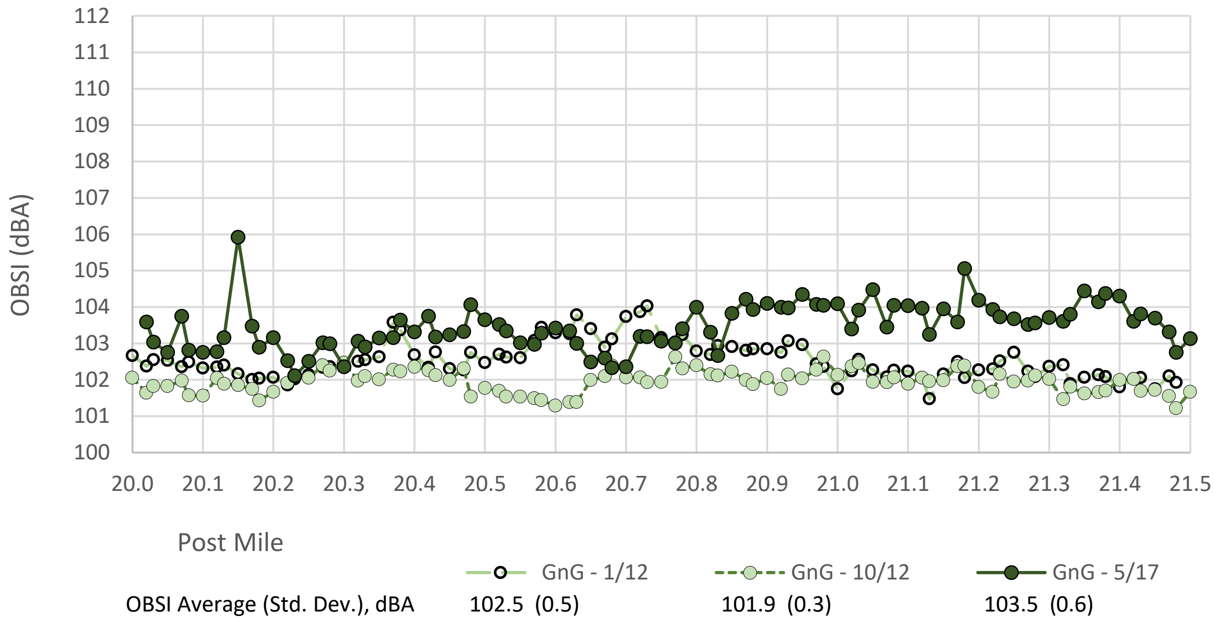

Figure A.7: Sac5N1PM20.0/21.5 OBSI data.

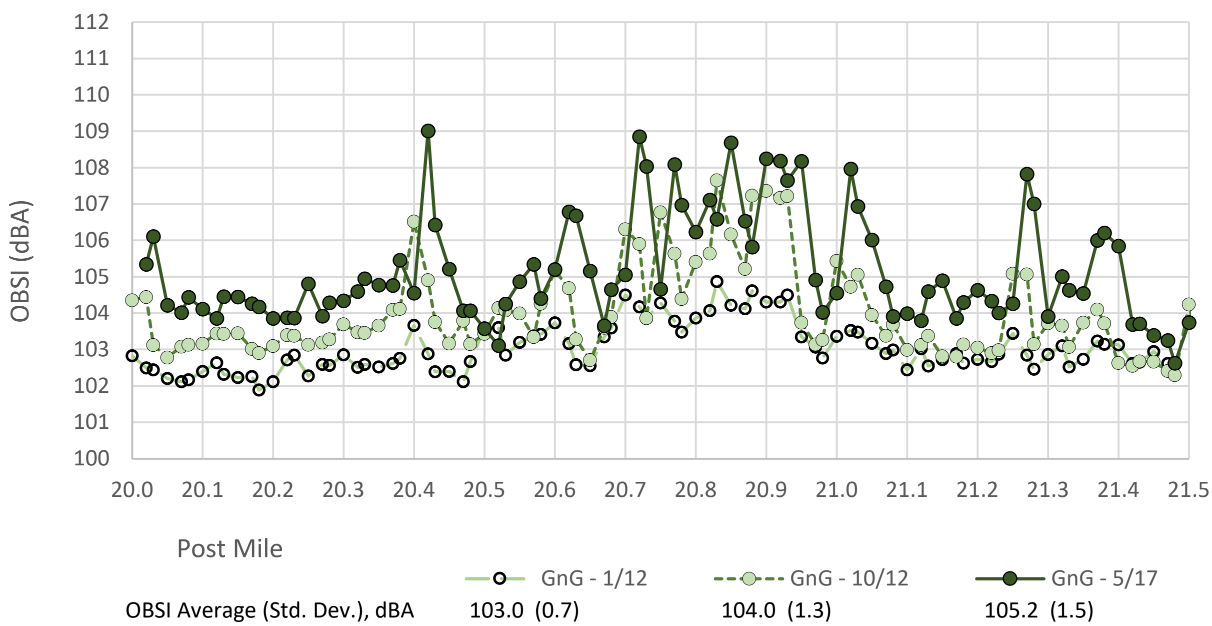

Figure A.8: Sac5N4PM20.0/21.5 OBSI data.

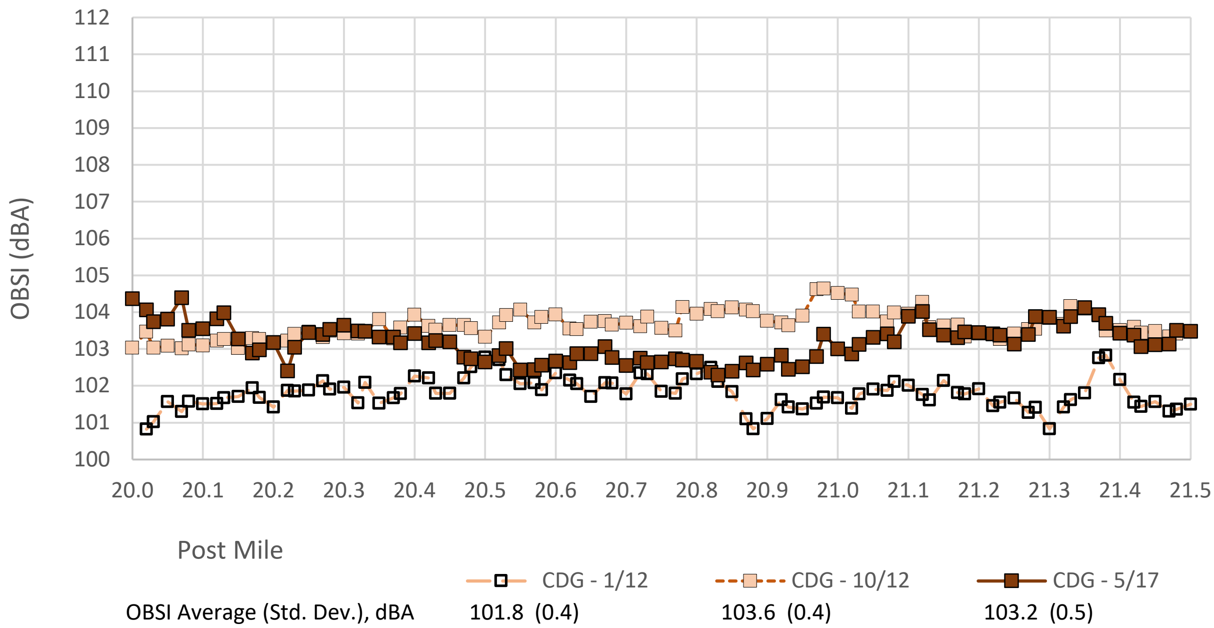

Figure A.9: Sac5S1PM20.0/21.5 OBSI data.

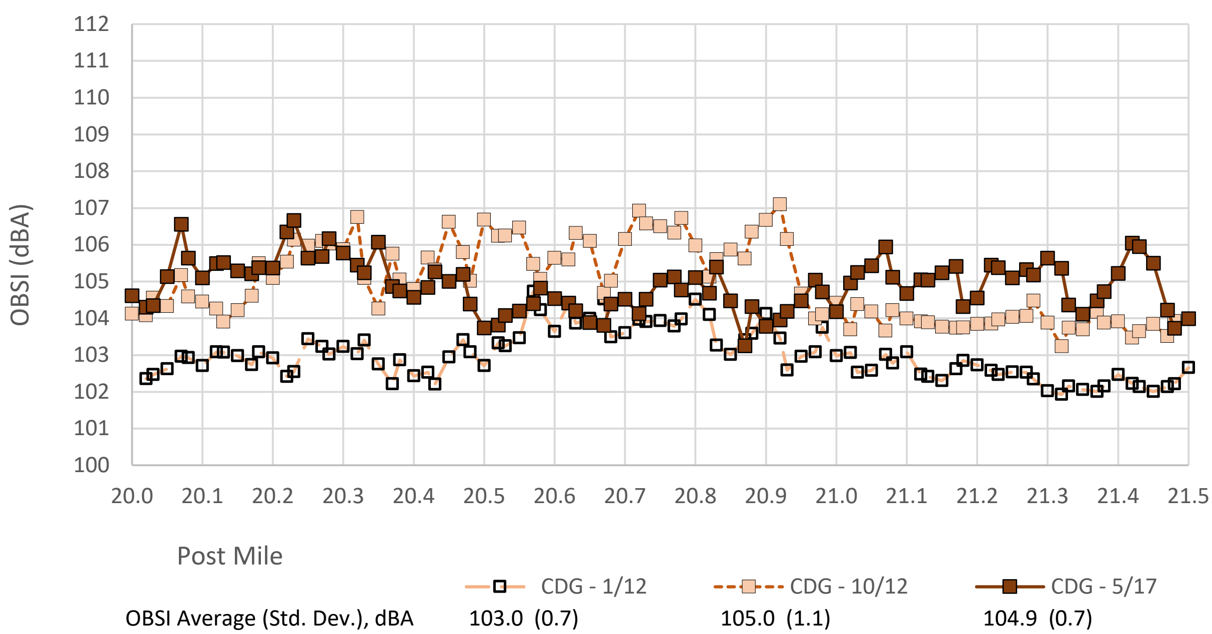

Figure A.10: Sac5S4PM20.0/21.5 OBSI data.

A.3 Sacramento 5 – PM 1.5/3.0

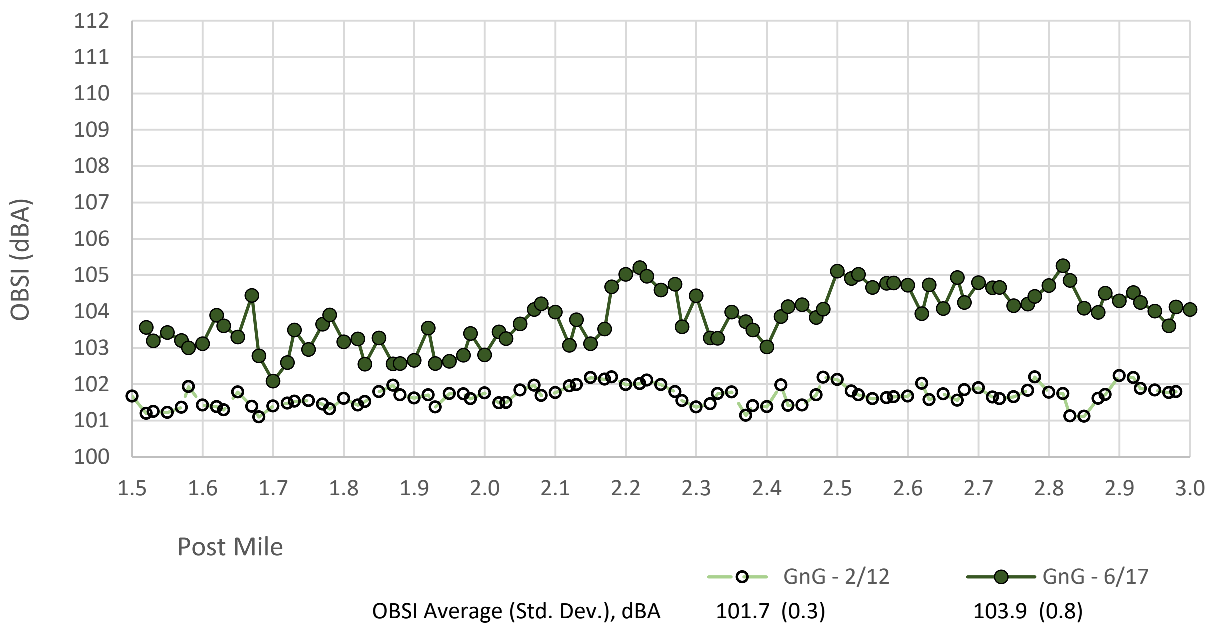

Figure A.11: Sac5N1PM1.5/3.0 OBSI data.

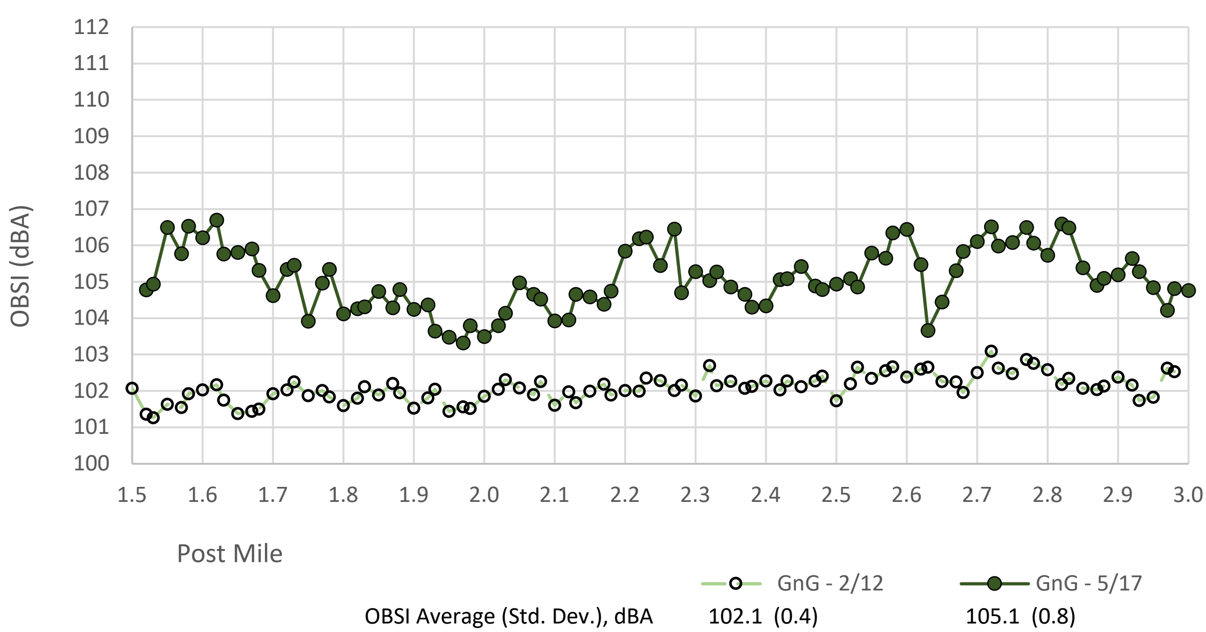

Figure A.12: Sac5N2PM1.5/3.0 OBSI data.

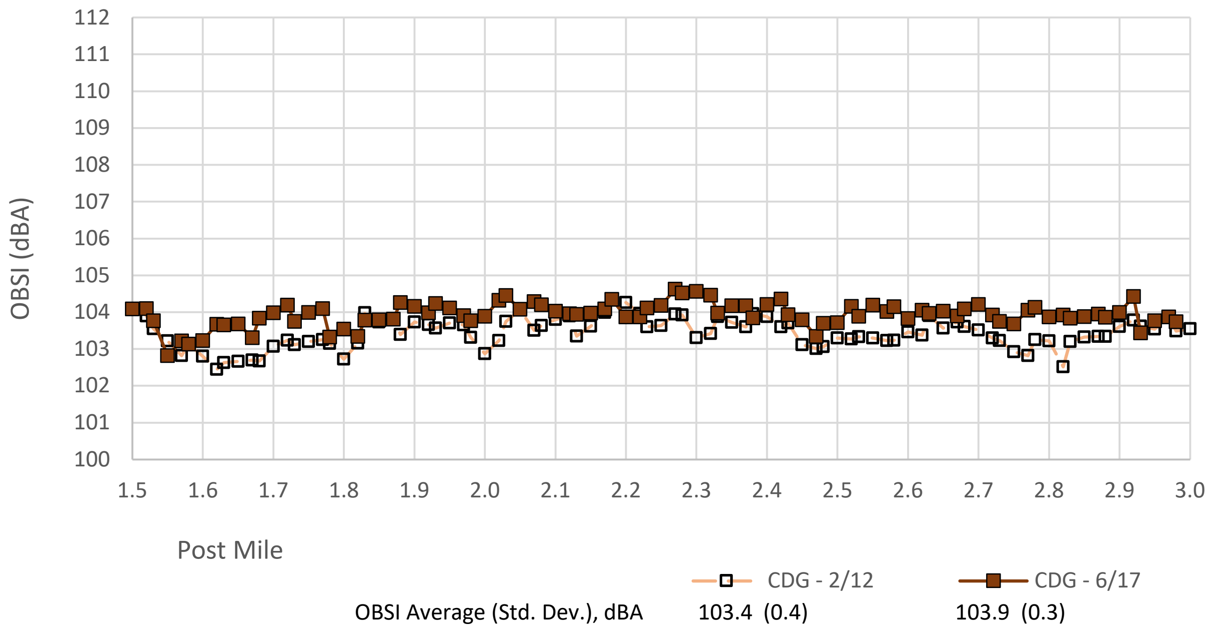

Figure A.13: Sac5S1PM1.5/3.0 OBSI data.

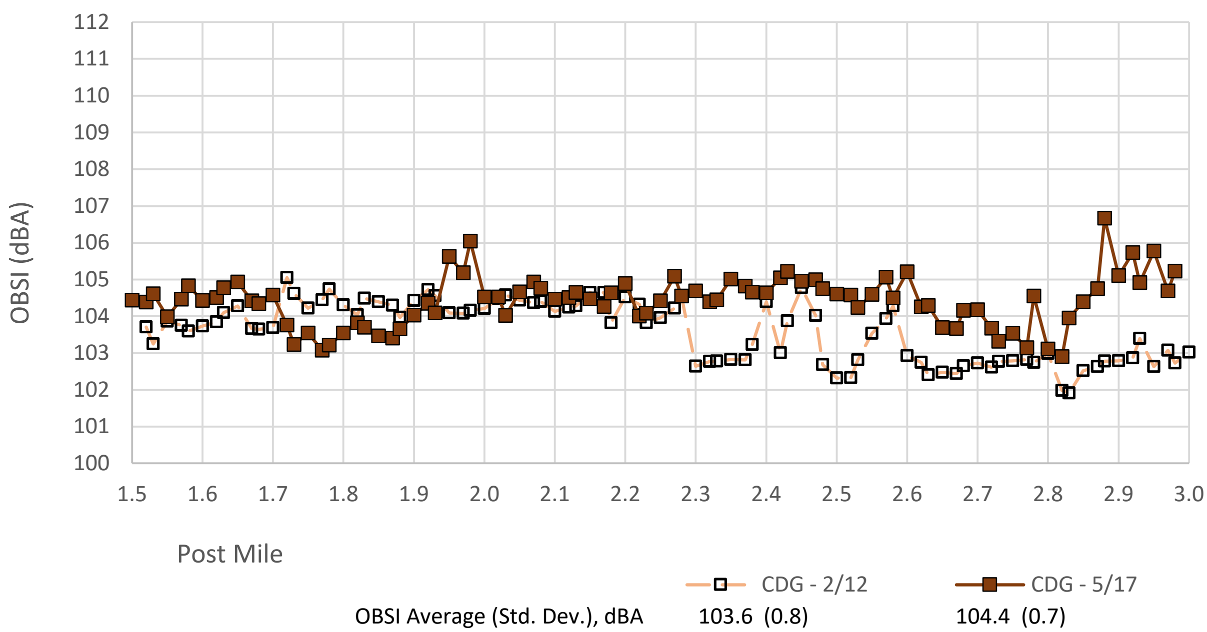

Figure A.14: Sac5S2PM1.5/3.0 OBSI data.

A.4 Sacramento 80 – PM 13.0/14.0

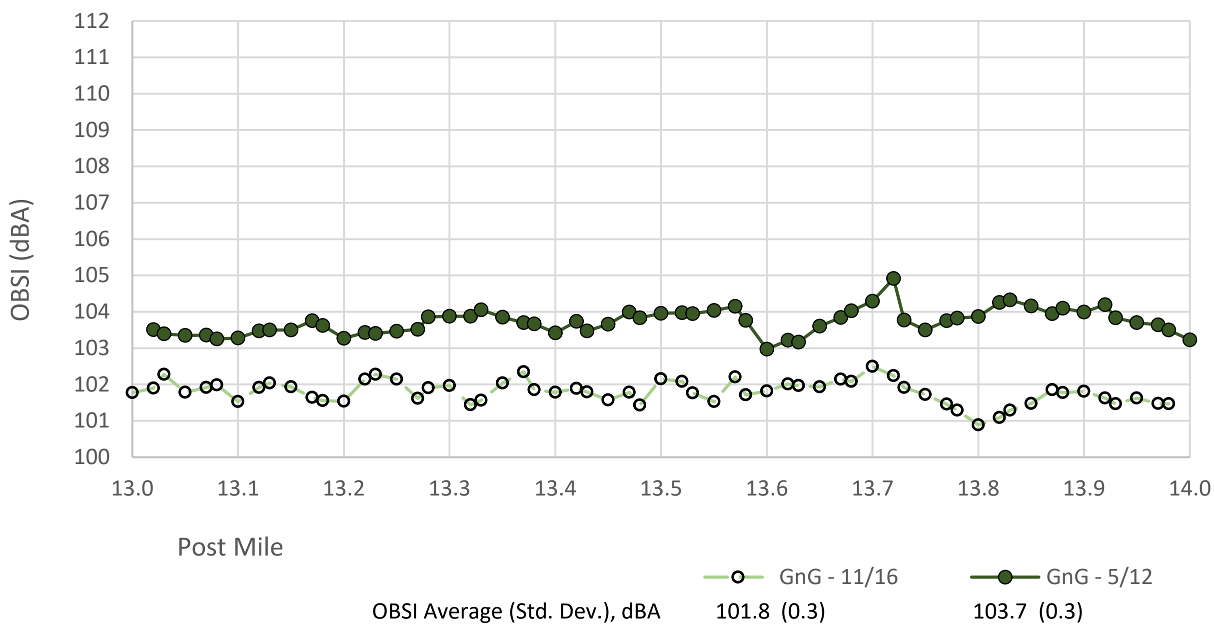

Figure A.15: Sac80E2PM13.0/14.0 OBSI data.

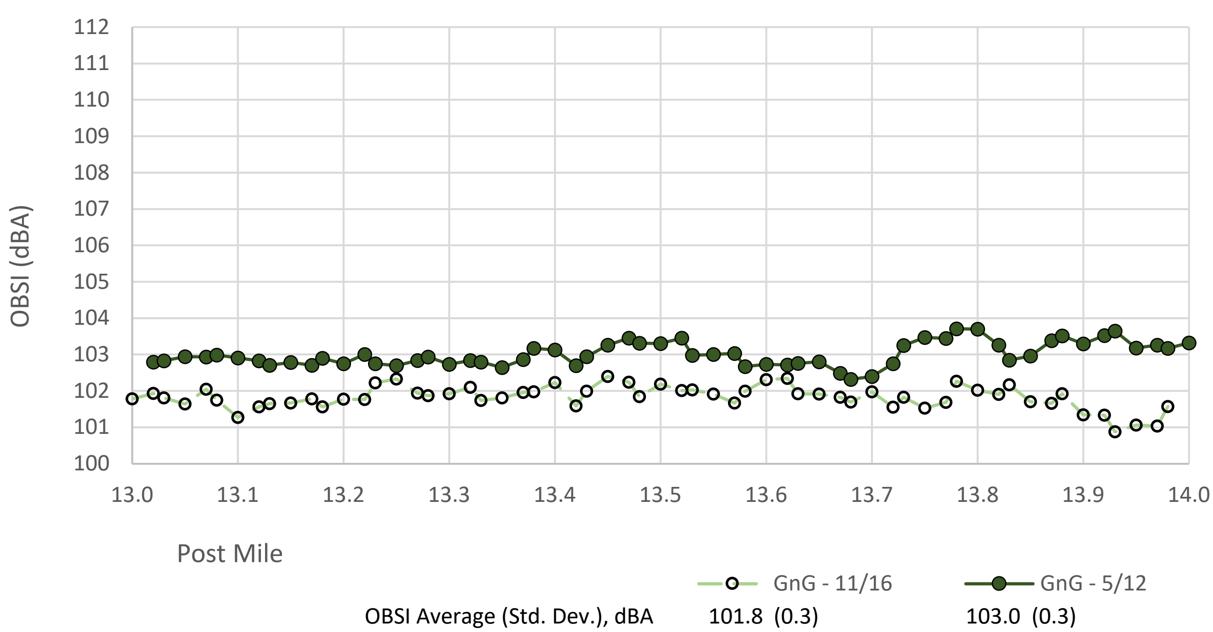

Figure A.16: Sac80E5PM13.0/14.0 OBSI data.

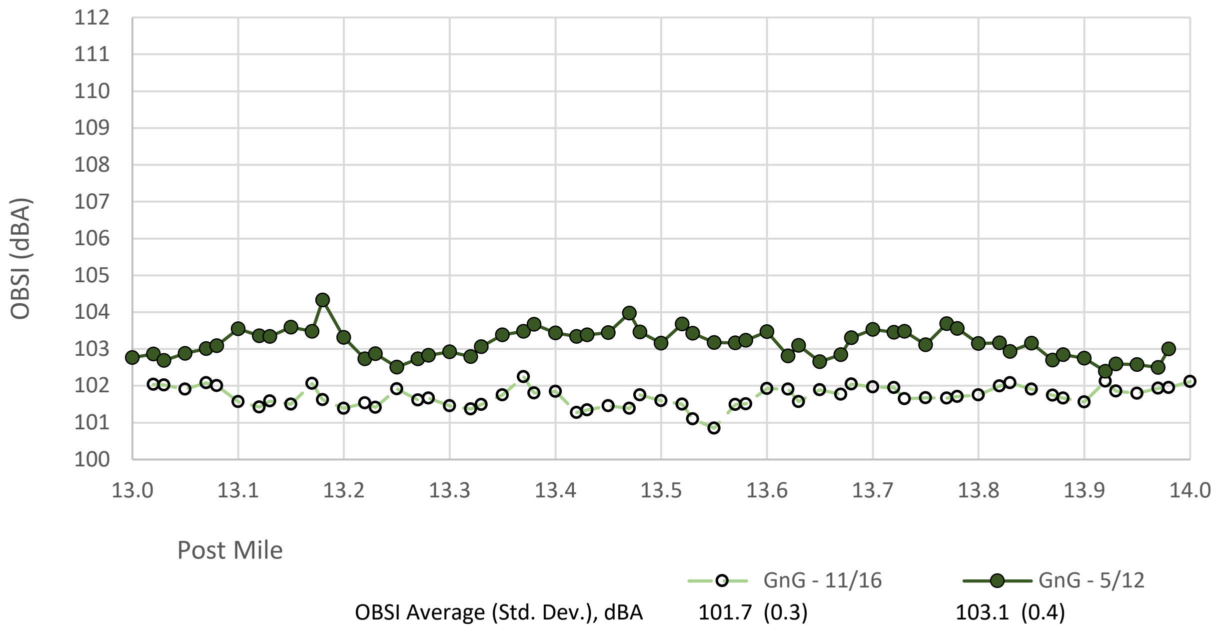

Figure A.17: Sac80W2PM13.0/14.0 OBSI data.

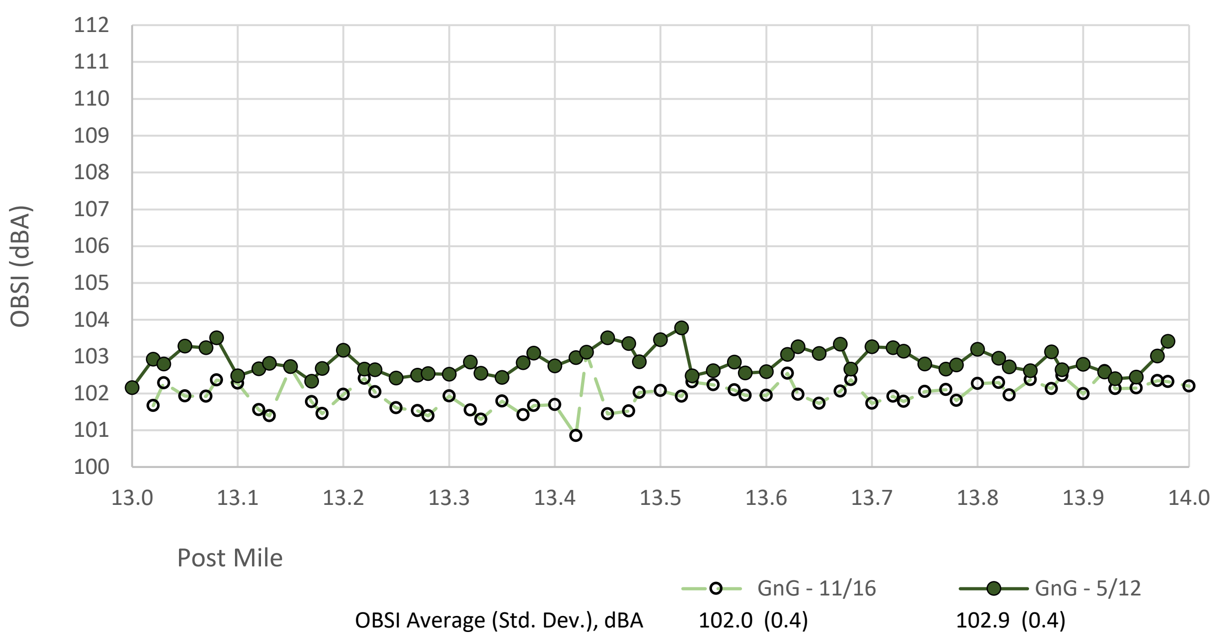

Figure A.18: Sac80W5PM13.0/14.0 OBSI data.

A.5 Sacramento 50 – PM 13.0/14.0

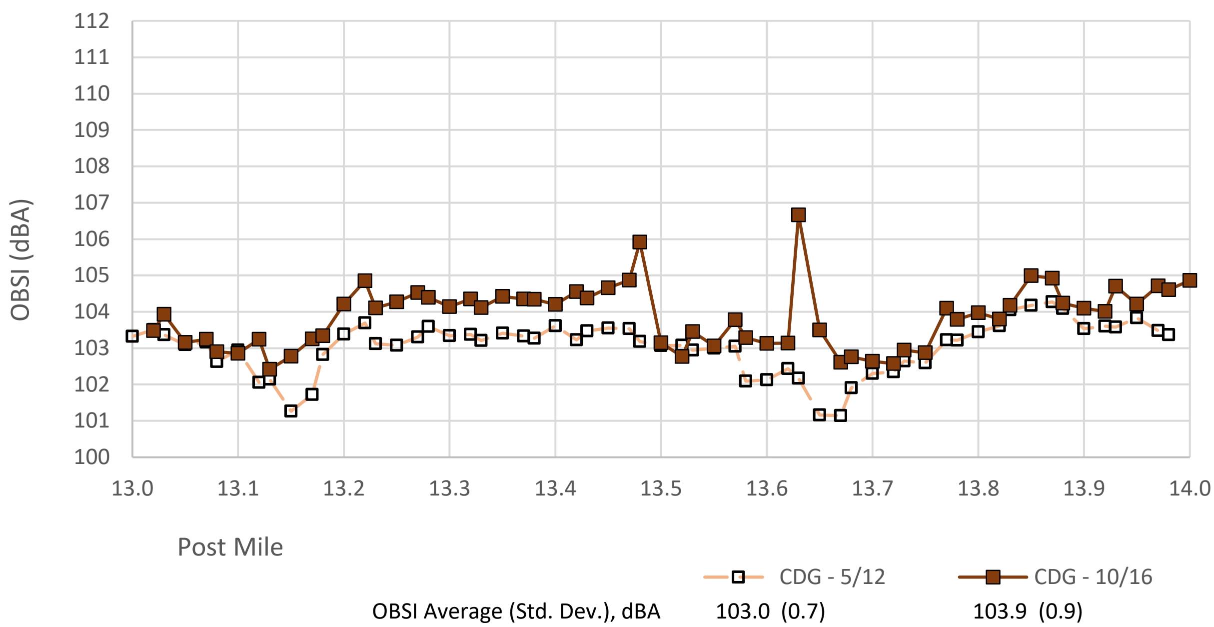

Figure A.19: Sac50E2PM13.0/14.0 OBSI data.

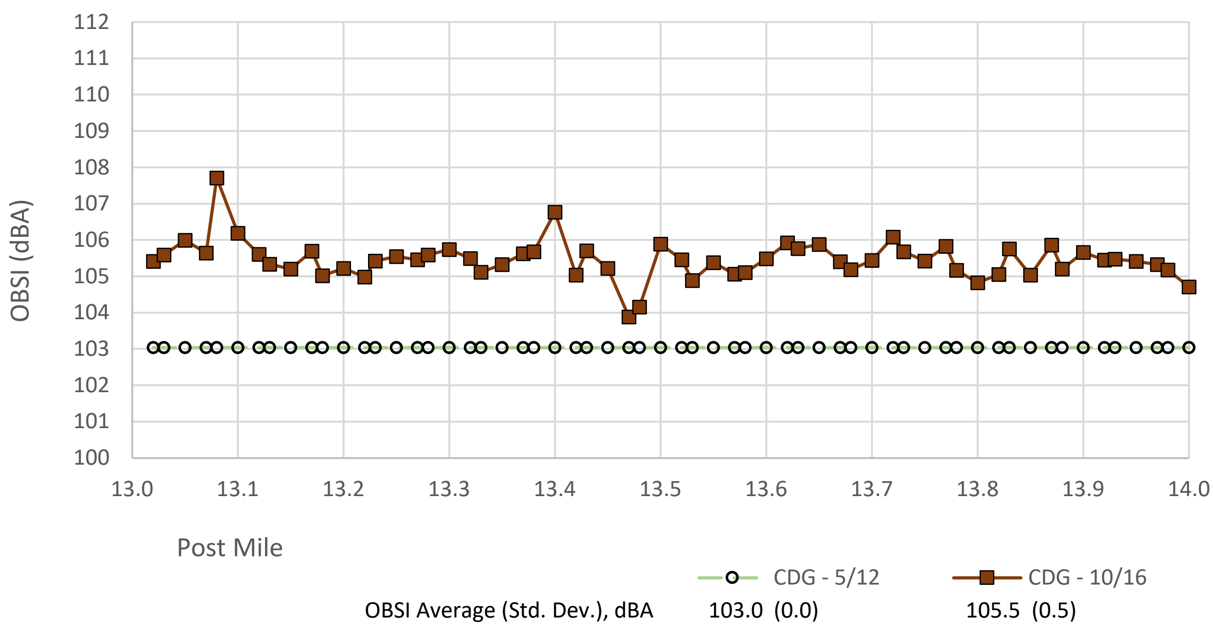

Figure A.20: Sac50E4PM13.0/14.0 OBSI data.

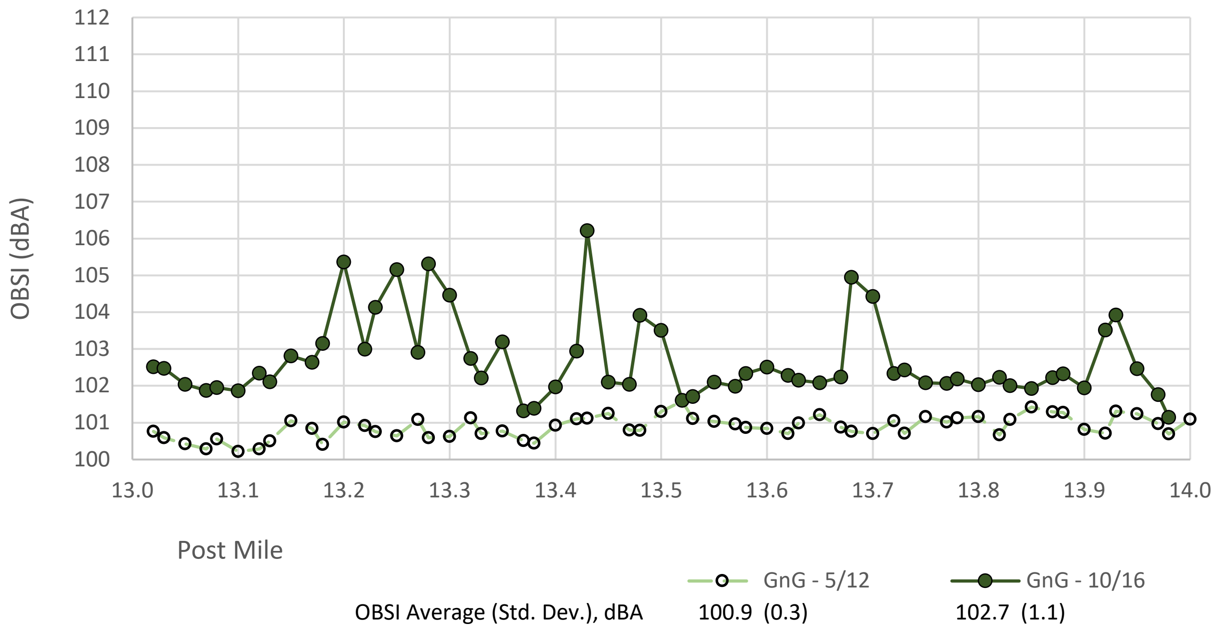

Figure A.21: Sac50W2PM13.0/14.0 OBSI data.

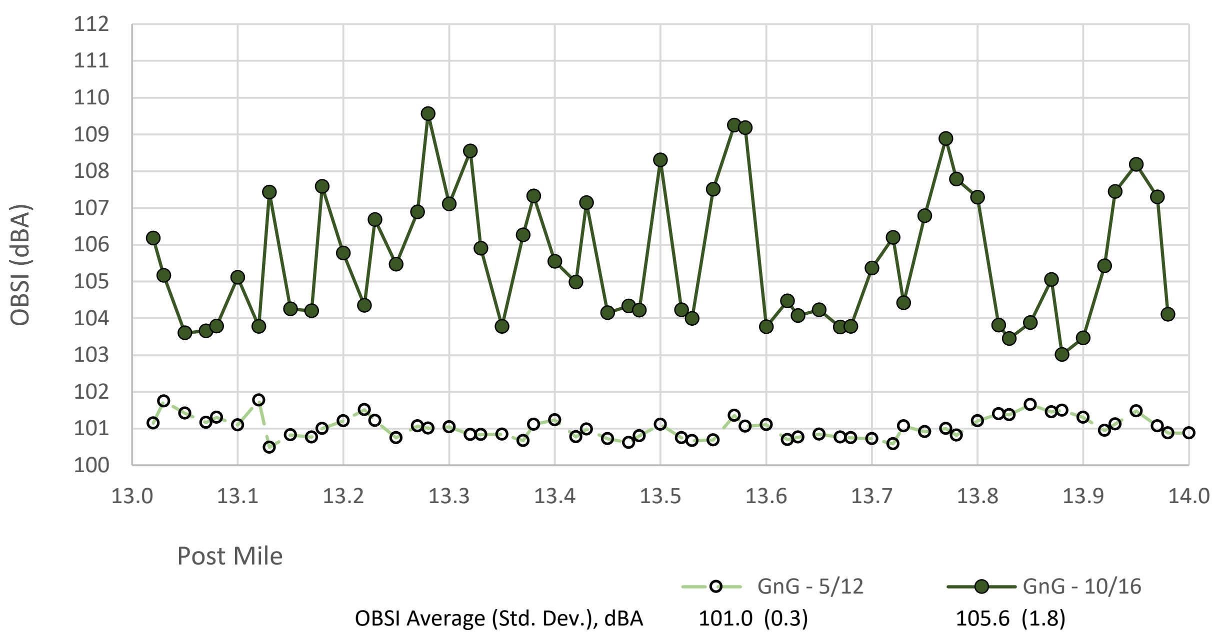

Figure A.22: Sac50W4PM13.0/14.0 OBSI data.

A.6 San Joaquin 99 – PM 29.0/30.5

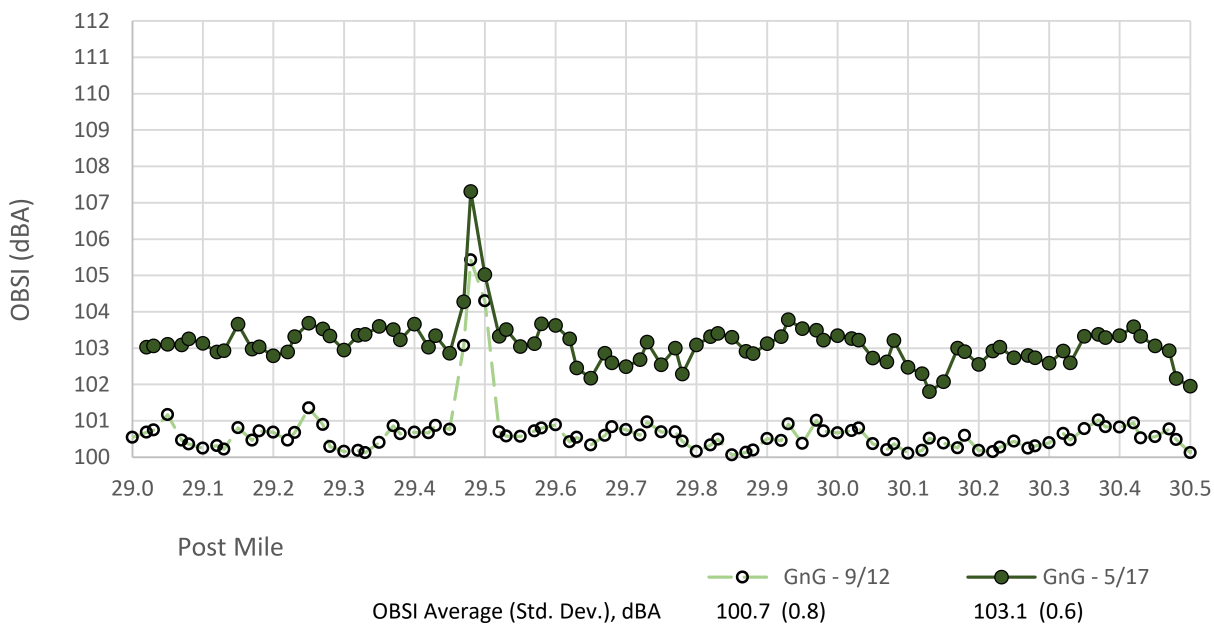

Figure A.23: SJ99N1PM29.0/30.5 OBSI data.

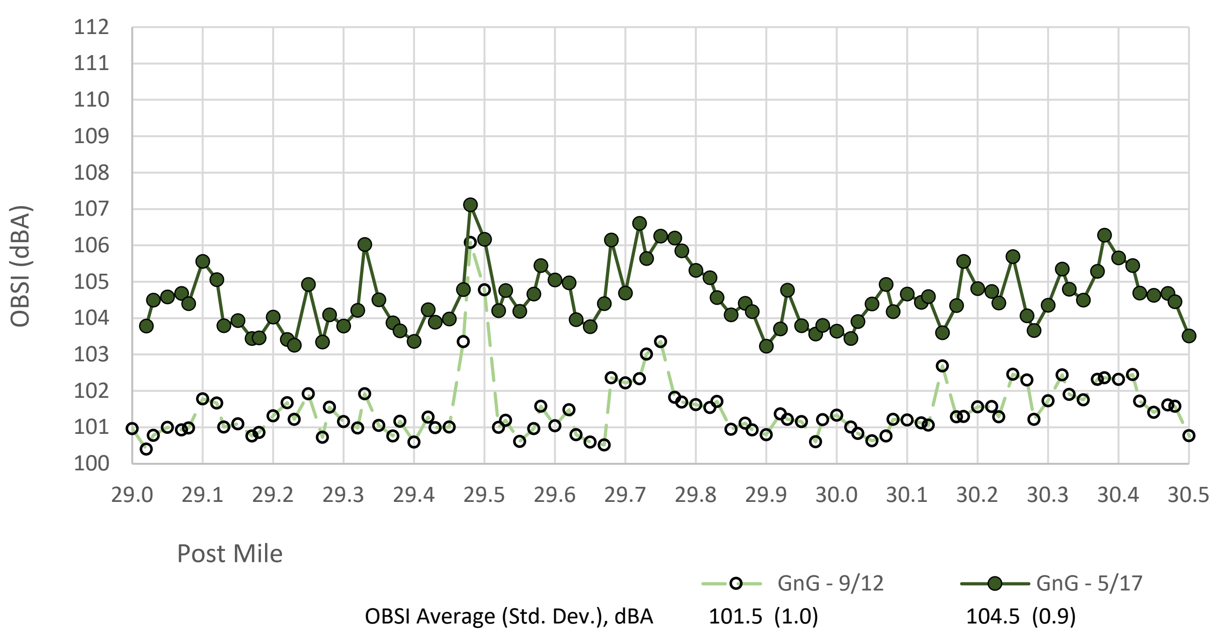

Figure A.24: SJ99N2PM29.0/30.5 OBSI data.

A.7 Yolo 113 – PM 0.5/2.5

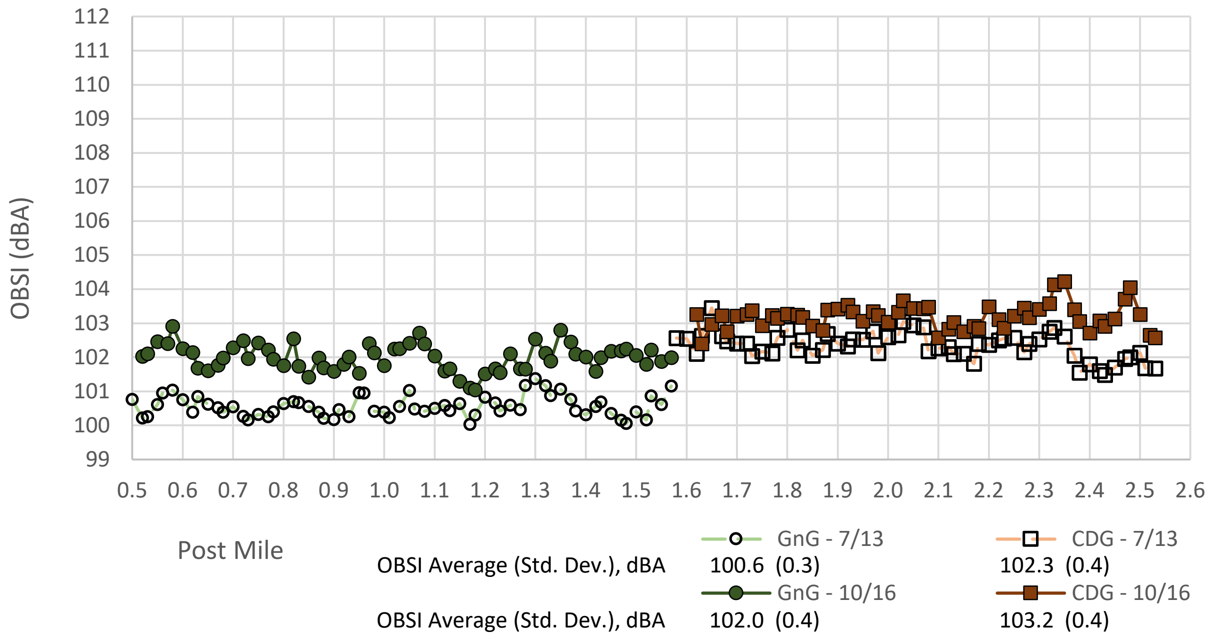

Figure A.25: Yol113N1PM0.5/2.5 OBSI data.

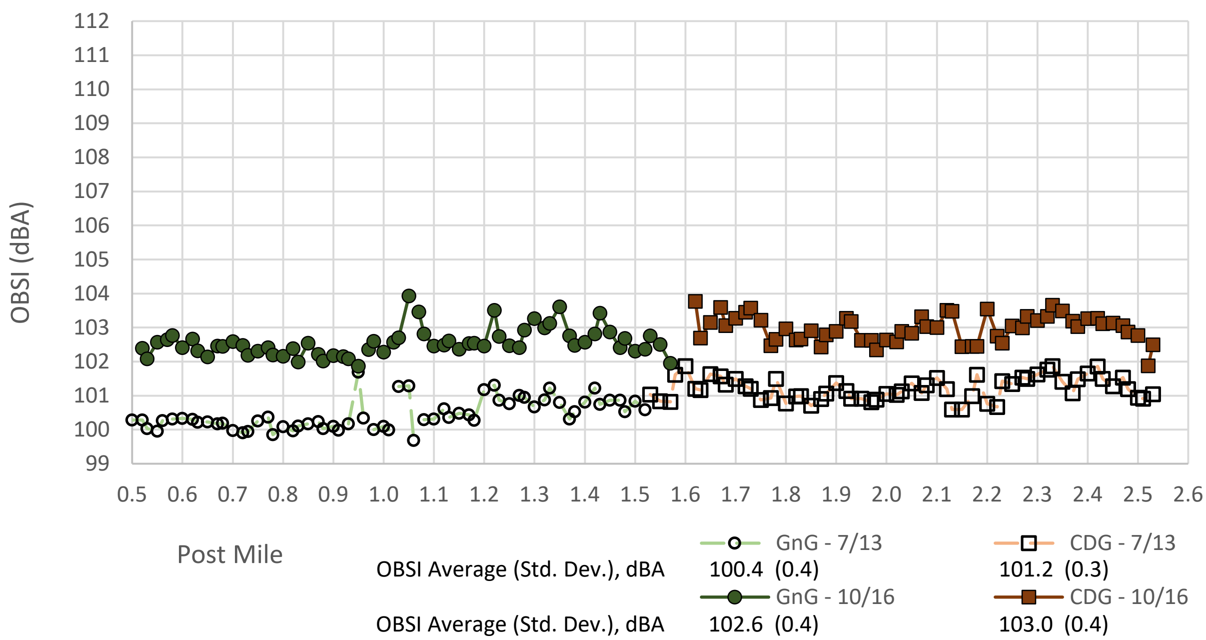

Figure A.26: Yol113N2PM0.5/2.5 OBSI data.

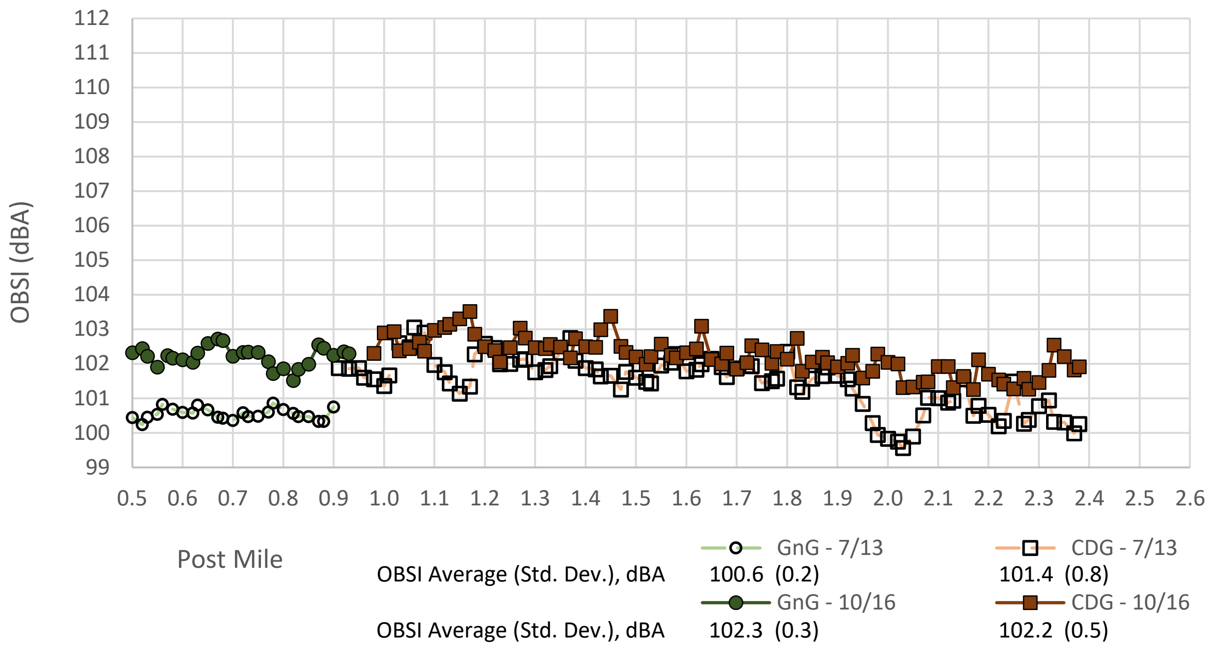

Figure A.27: Yol113S1PM0.5/2.5 OBSI data.

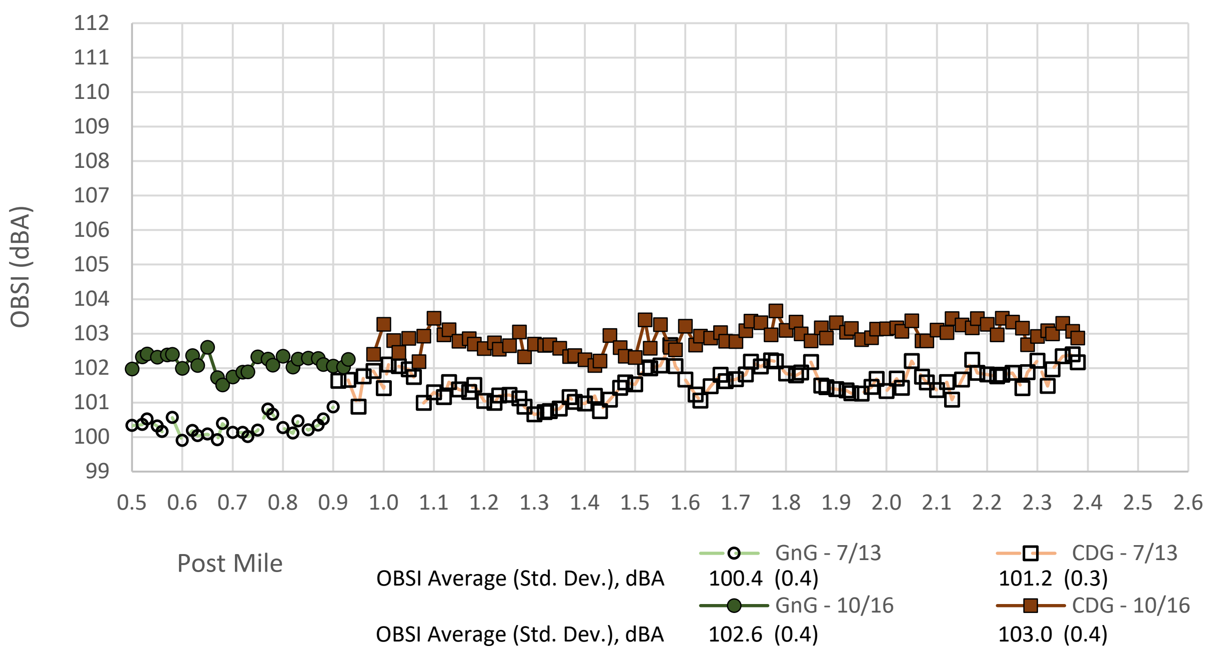

Figure A.28: Yol113S2PM0.5/2.5 OBSI data.

A.8 San Diego 5 – PM 35.8/37.9

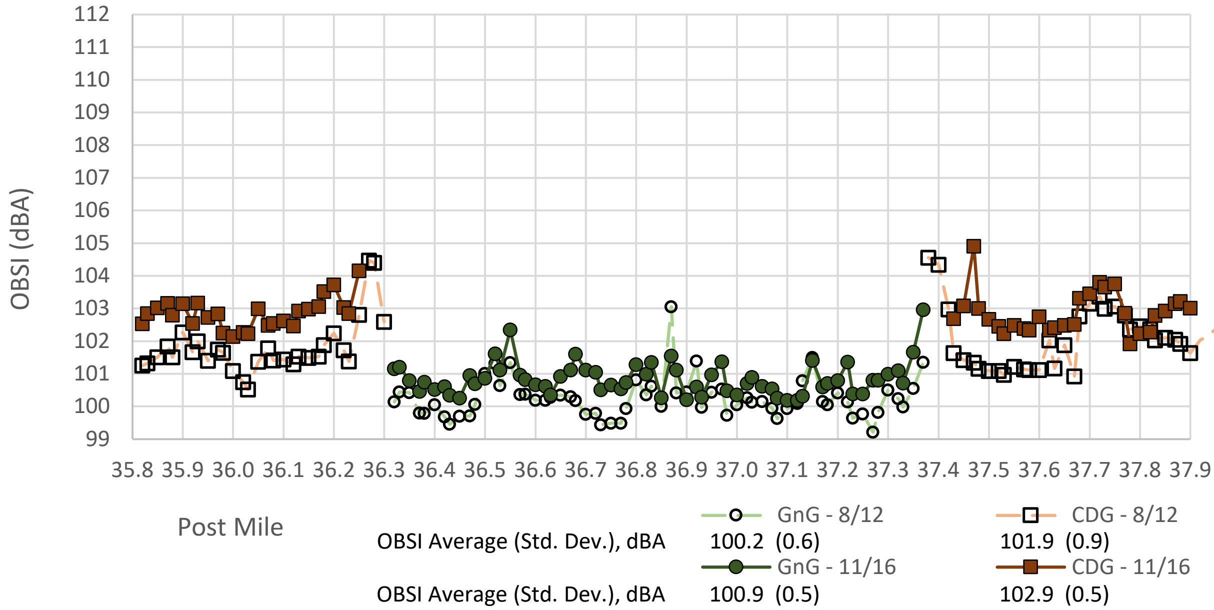

Figure A.29: SD5N1PM35.8/37.9 OBSI data.

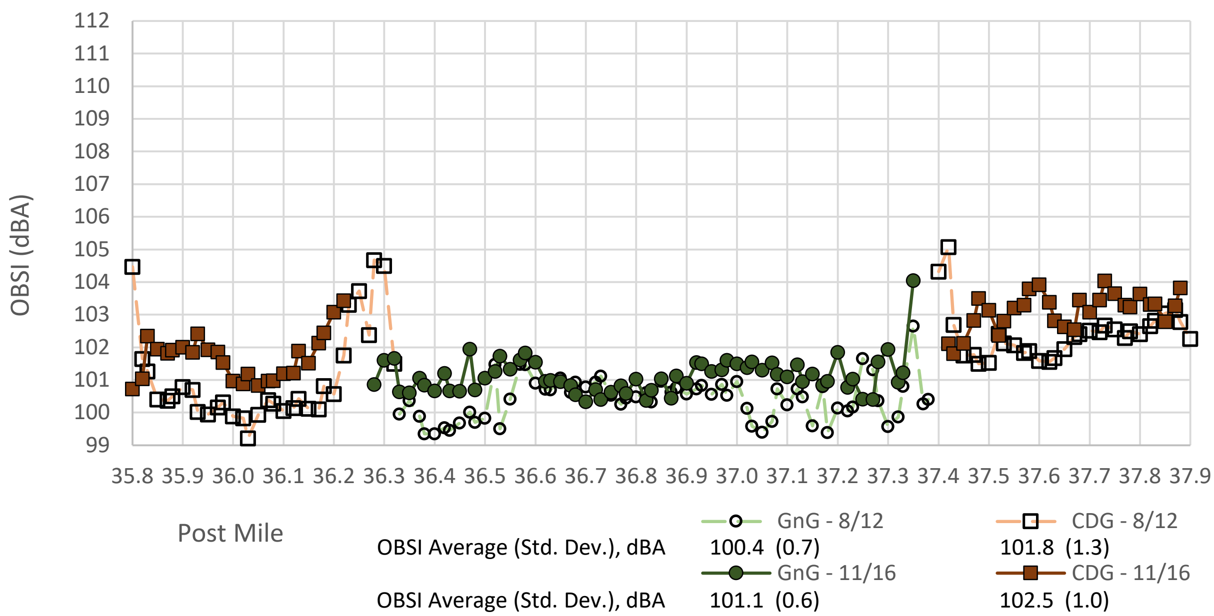

Figure A.30: SD5S1PM35.8/37.9 OBSI data.

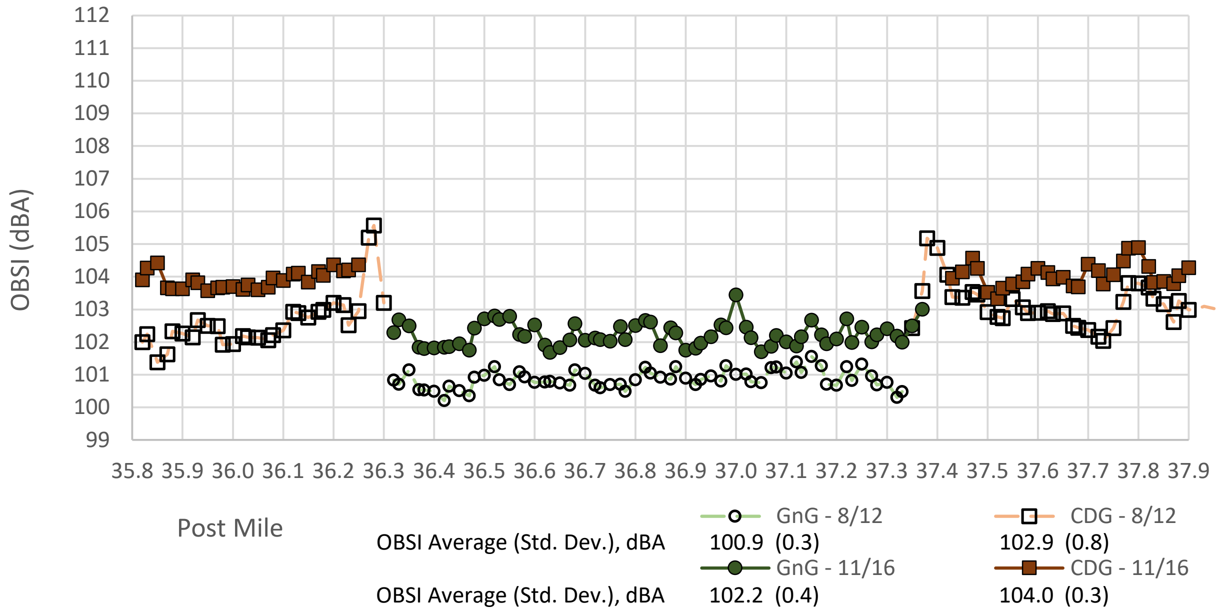

Figure A.31: SD5N2PM35.8/37.9 OBSI data.

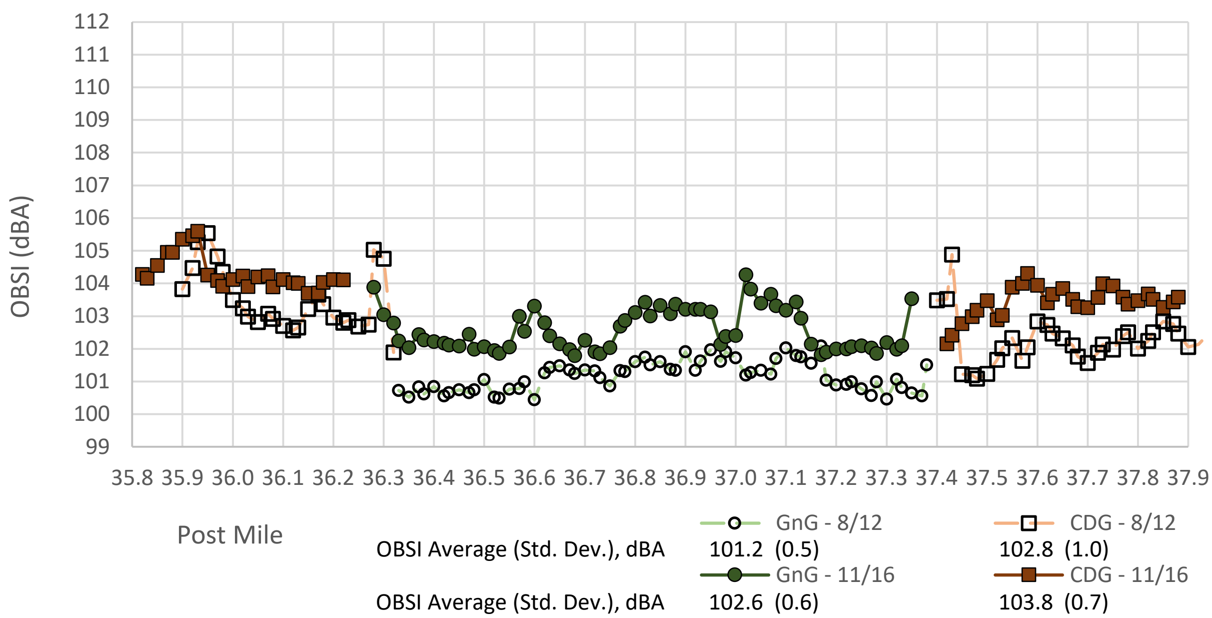

Figure A.32: SD5S2PM35.8/37.9 OBSI data.

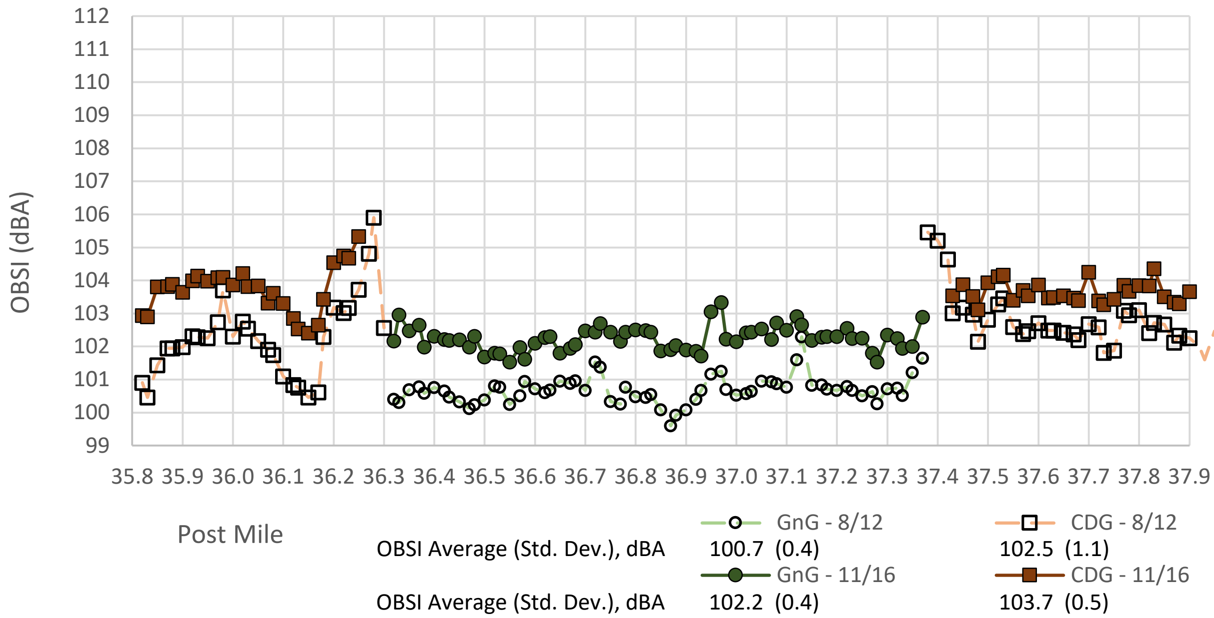

Figure A.33: SD5N3PM35.8/37.9 OBSI data.

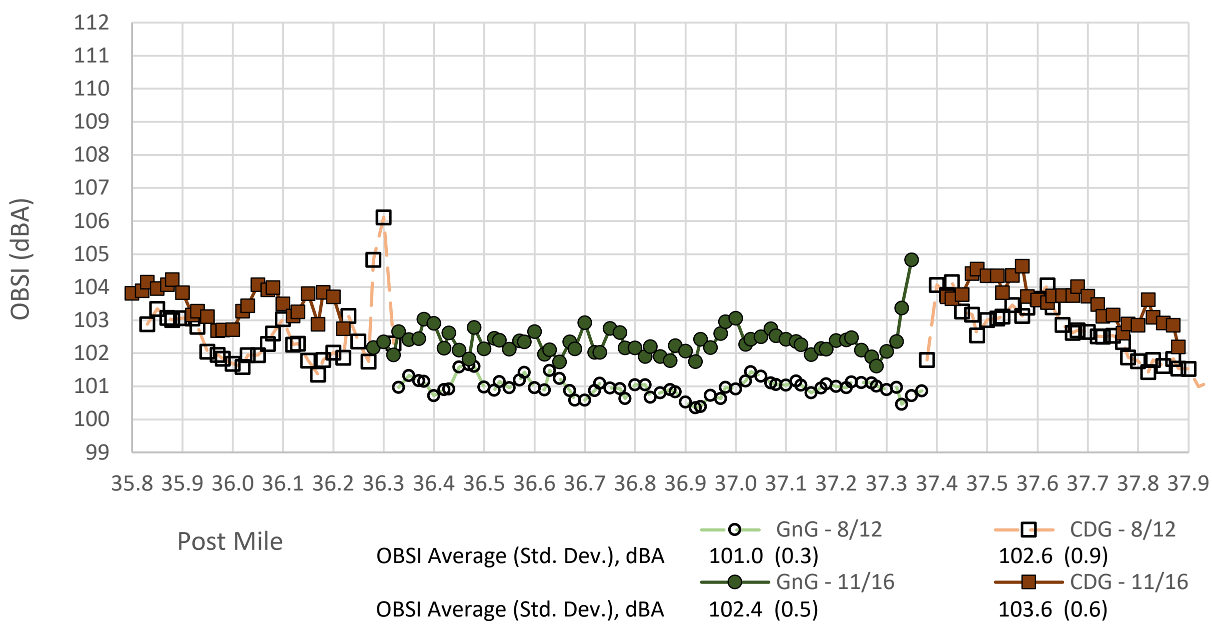

Figure A.34: SD5S3PM35.8/37.9 OBSI data.

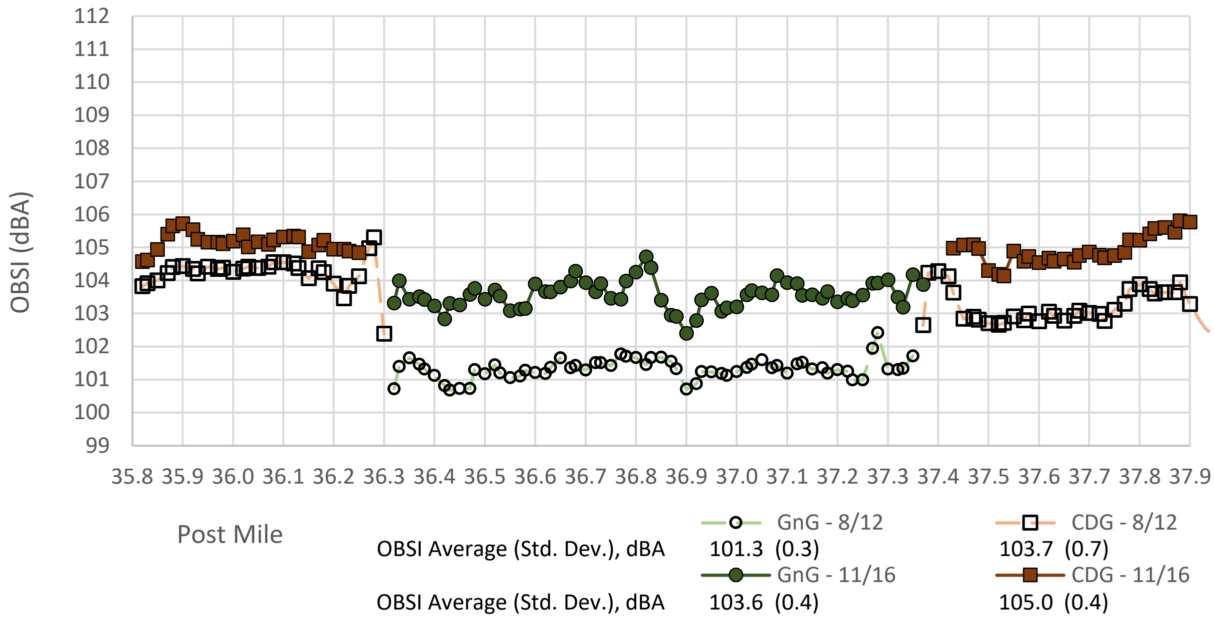

Figure A.35: SD5N4PM35.8/37.9 OBSI data.

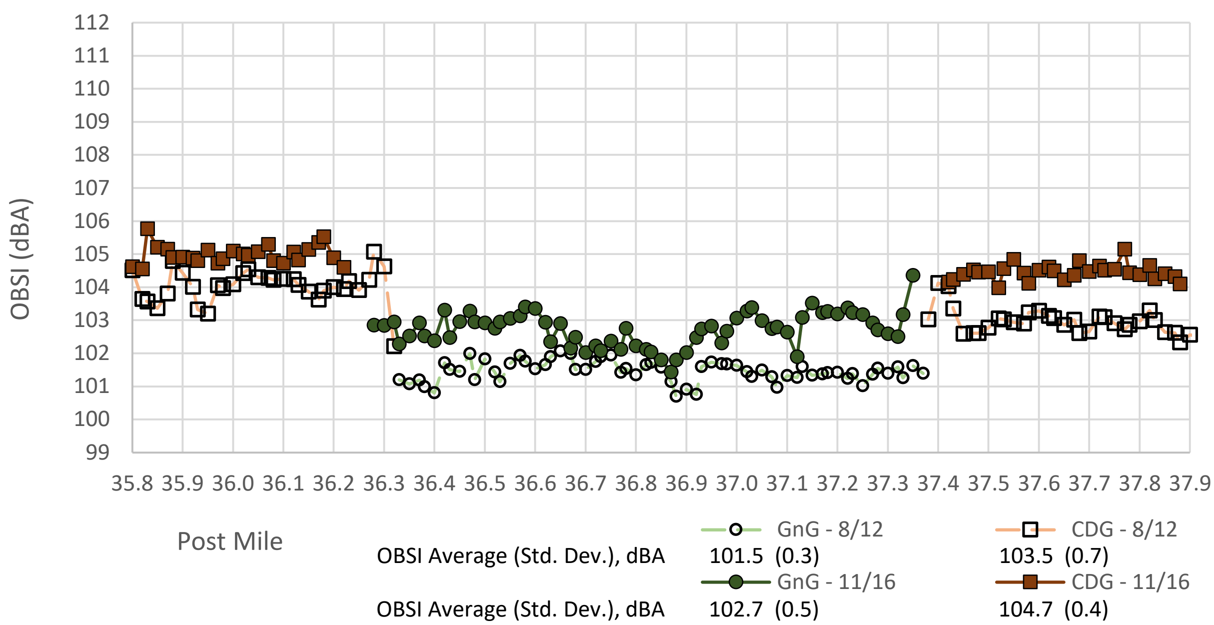

Figure A.36: SD5S4PM35.8/37.9 OBSI data.

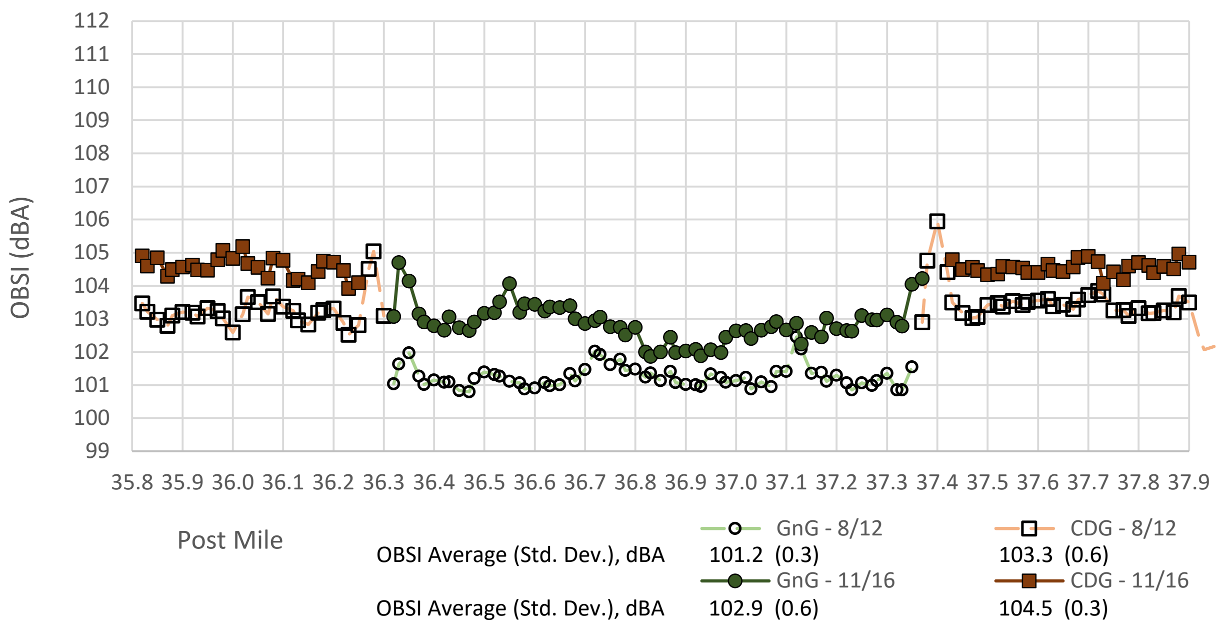

Figure A.37: SD5N5PM35.8/37.9 OBSI data.

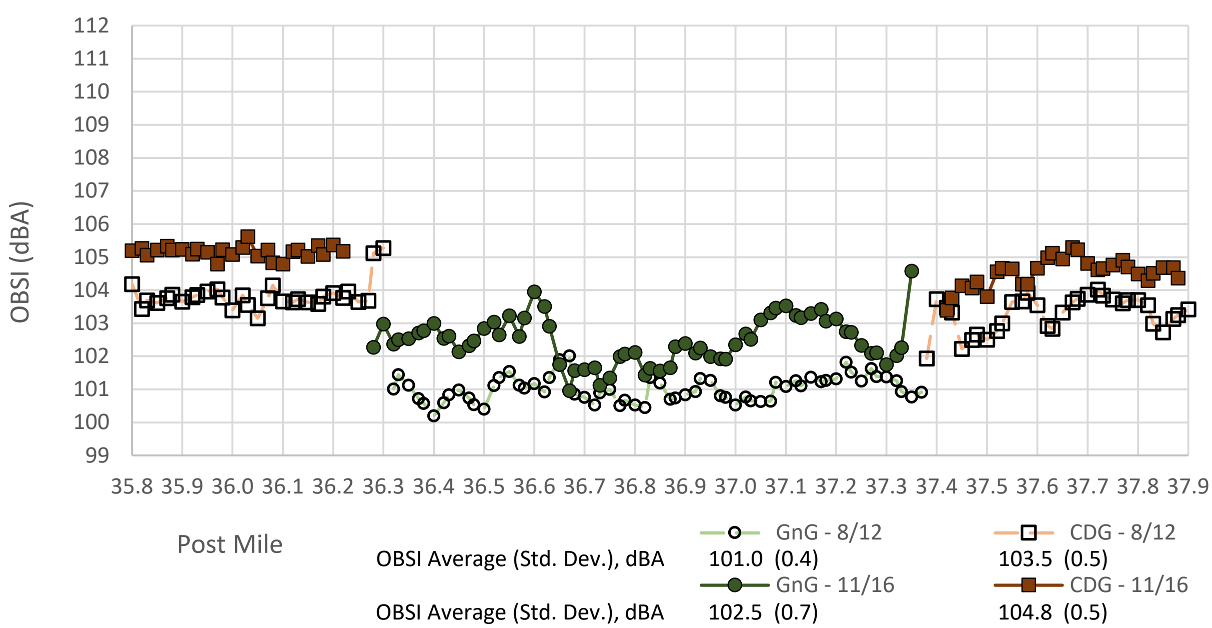

Figure A.38: SD5S5PM35.8/37.9 OBSI data.

APPENDIX B IRI LONGITUDINAL PROFILES

Longitudinal profiles of IRI for selected sections are presented in the following figures. Each profile is an individual lane, with a direction and lane number indicated in the figure header. The figure legend provides the month and year of the two sampling periods, as some project data were collected over multiple days.

The JPCP profiles from Yol113 and SD5 follow the CRCP profiles in Section B.1. Both JPCP projects have longitudinal profiles that show the transition between the GnG and CDG textures. The Yol113 profiles are paired by direction for each project in Section B.2. For example, the Yol113 charts for northbound Lane 1 and northbound Lane 2 are paired on the same page and southbound Lane 1 and southbound Lane 2 are paired. With different lanes in the same direction paired, the effect of truck traffic versus passenger car traffic may be evident.

The average IRI value and standard deviation IRI values for the longitudinal profiles are shown with the legend.

The following notation are used in the following figures:

- Dashed lines represent the older data.
- Solid lines represent the newer data.
- When there are three lines in a single figure, small dashes are the oldest data, longer dashes are an intermediate date, and the solid lines are the most recent data.

The section location is found in the figure caption, indicating the county and highway number, followed by the direction and lane number, concluding with the starting post mile (PM). For example, Plac80E1PM56.45 is located in Placer County on Highway 80 in the eastbound direction of Lane 1, starting at PM 56.45.

B.1 CRCP Pavement Sections

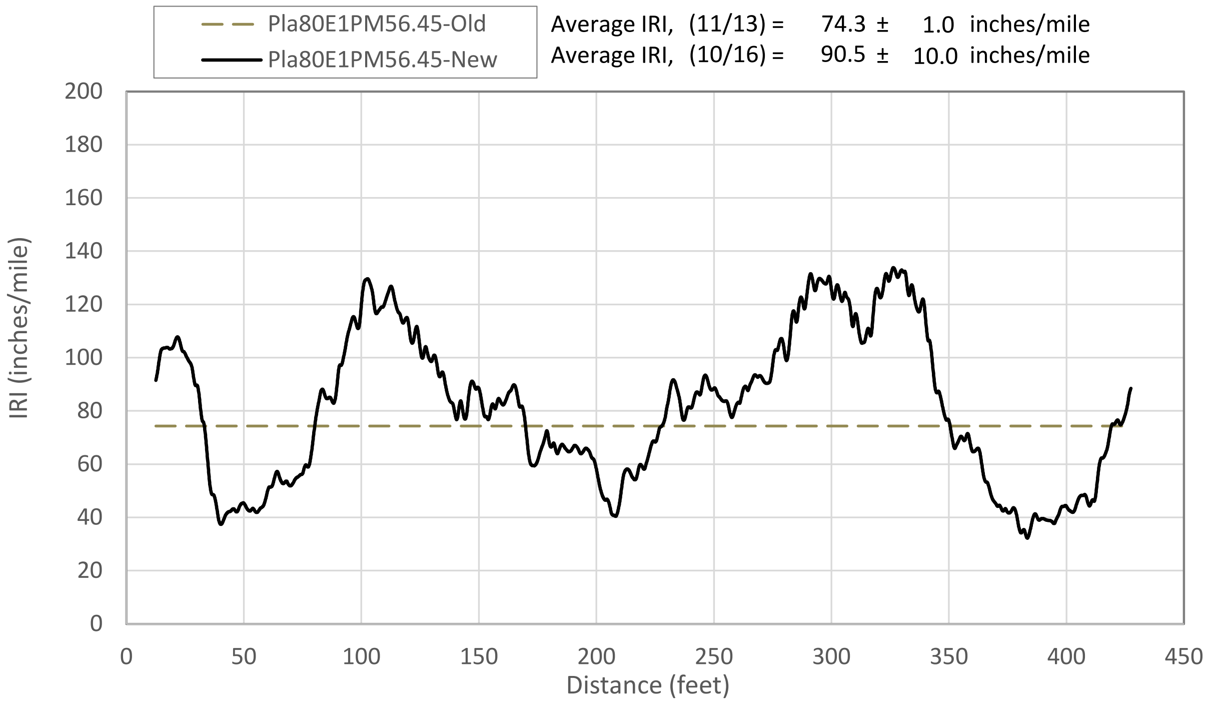

Figure B.1: Plac80E1PM56.45 IRI data.

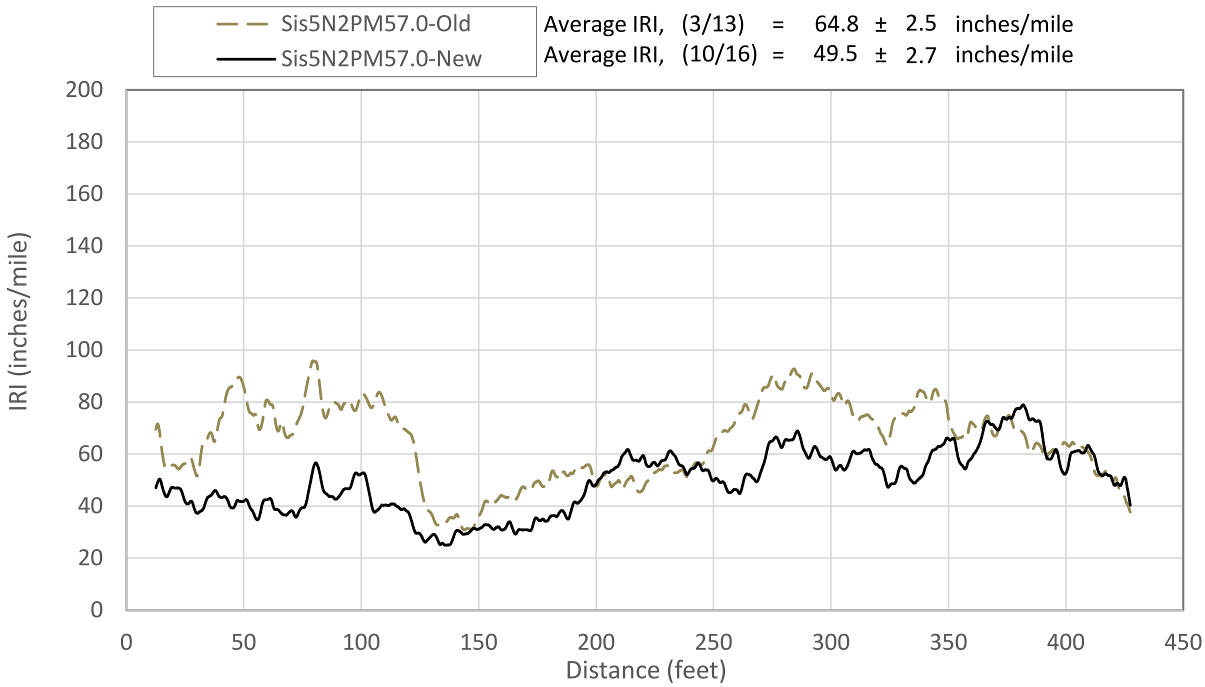

Figure B.2: Sis5N2PM57.0 IRI data.

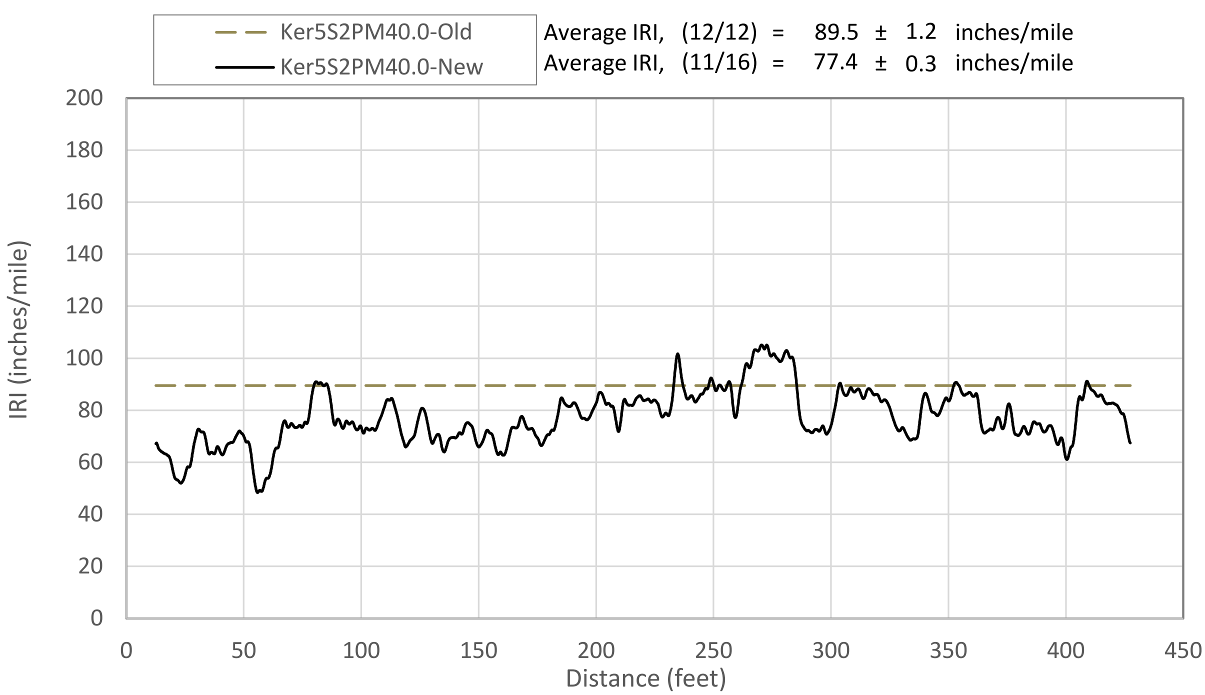

Figure B.3: Ker5S2PM40.0 IRI data.

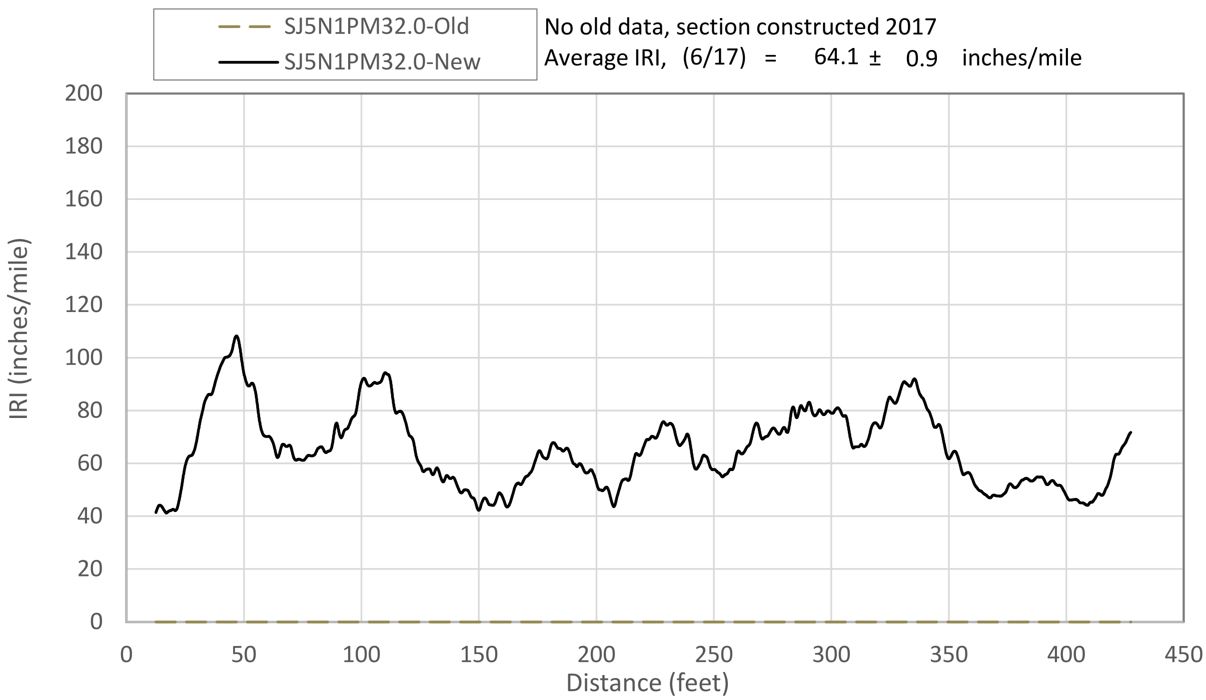

Figure B.4: SJ5N1PM32.0 IRI data.

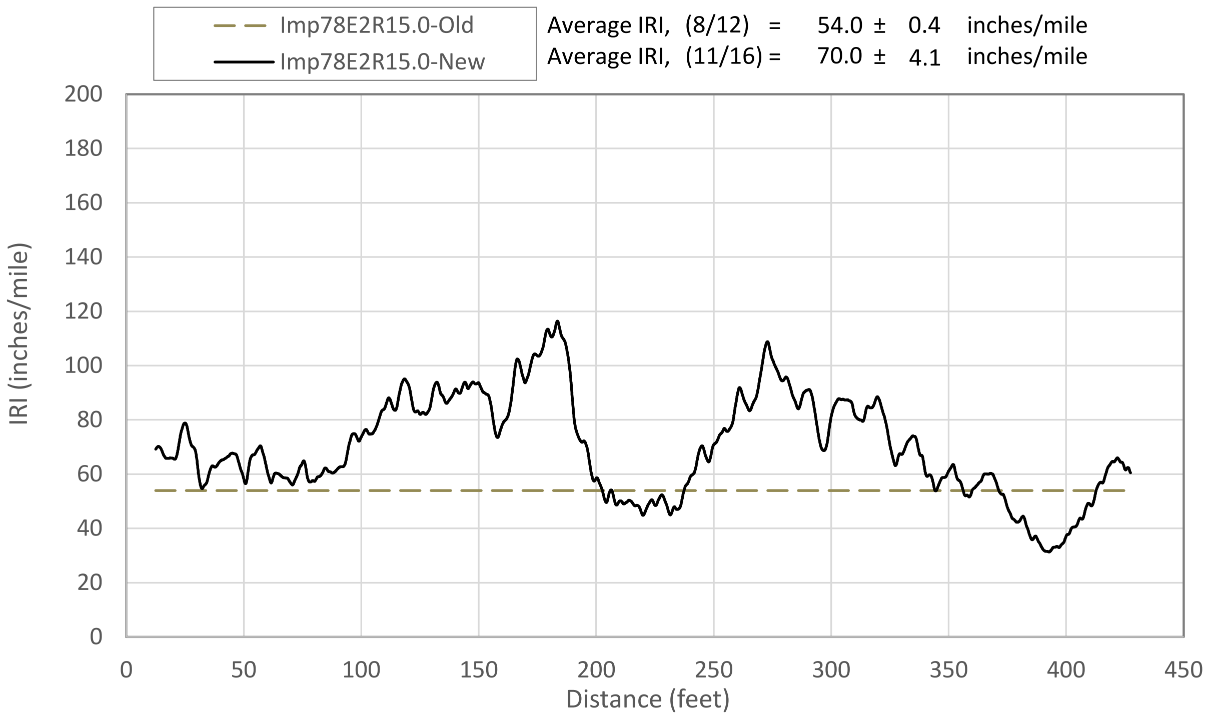

Figure B.5: Imp78E2PMR15.0 IRI data.

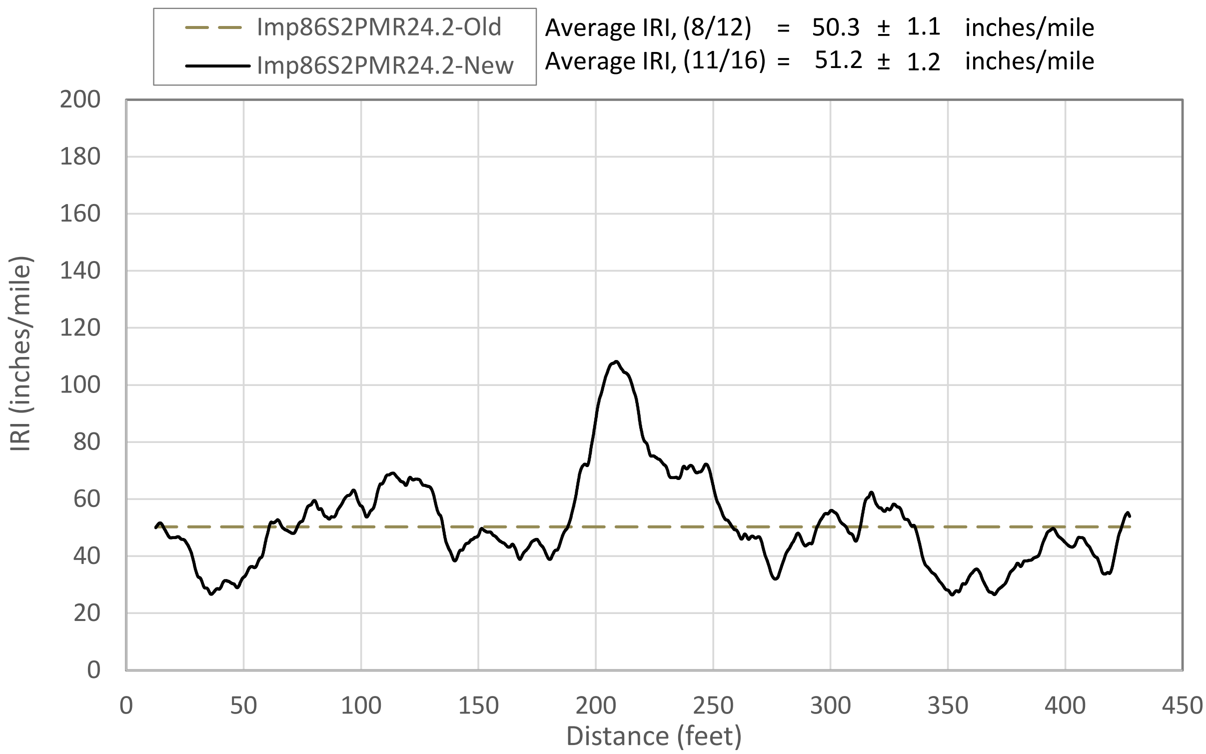

Figure B.6: Imp86S2PMR24.2 IRI data.

B.2 Yolo 113 – PM 0.5/2.5

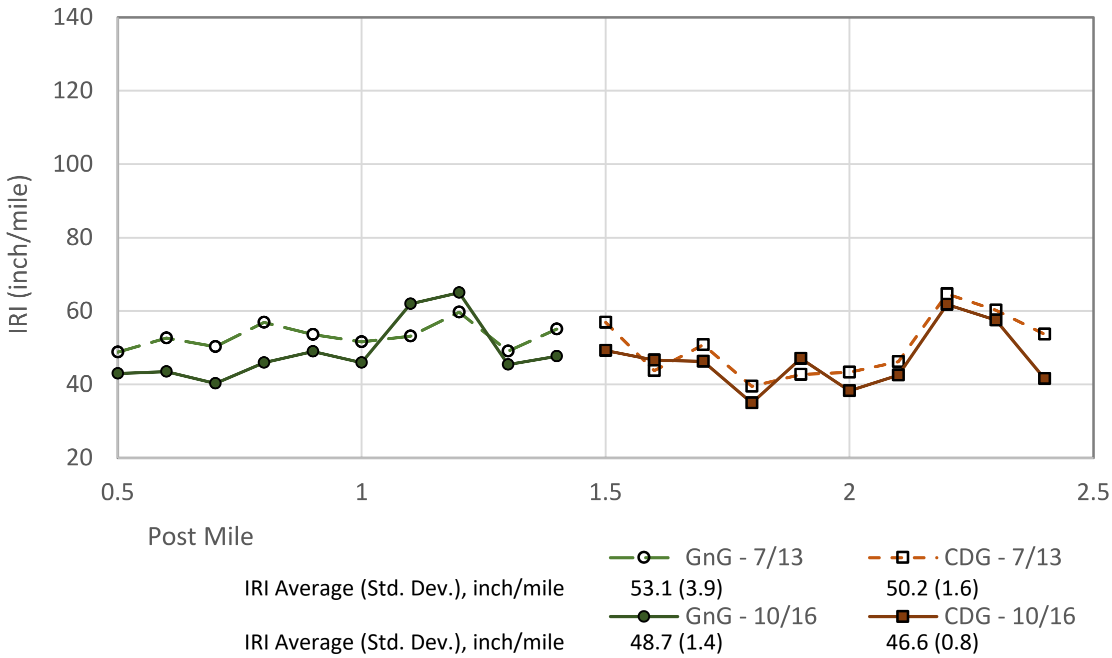

Figure B.7: Yol113N1PM0.5/2.5 IRI data.

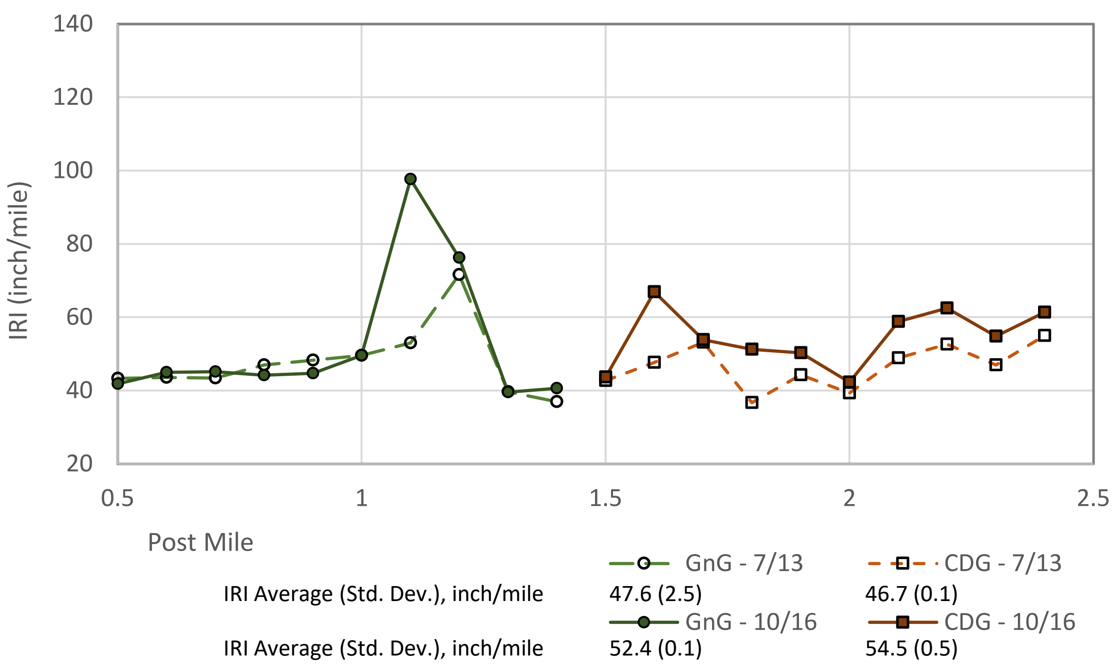

Figure B.8: Yol113N2PM0.5/2.5 IRI data.

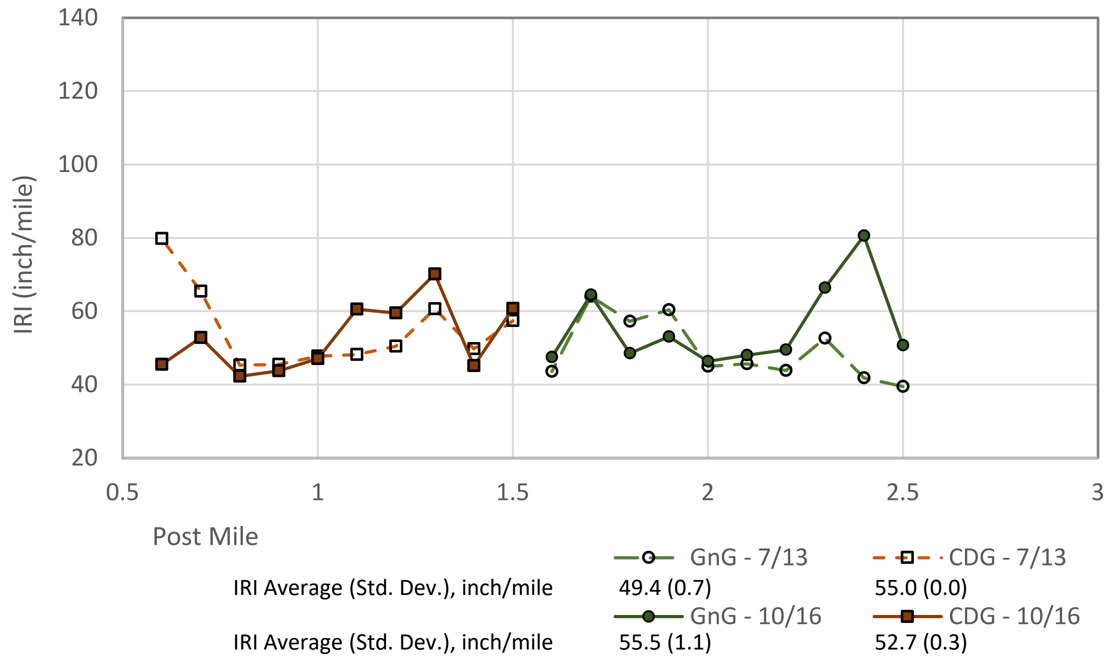

Figure B.9: Yol113S1PM0.5/2.5 IRI data.

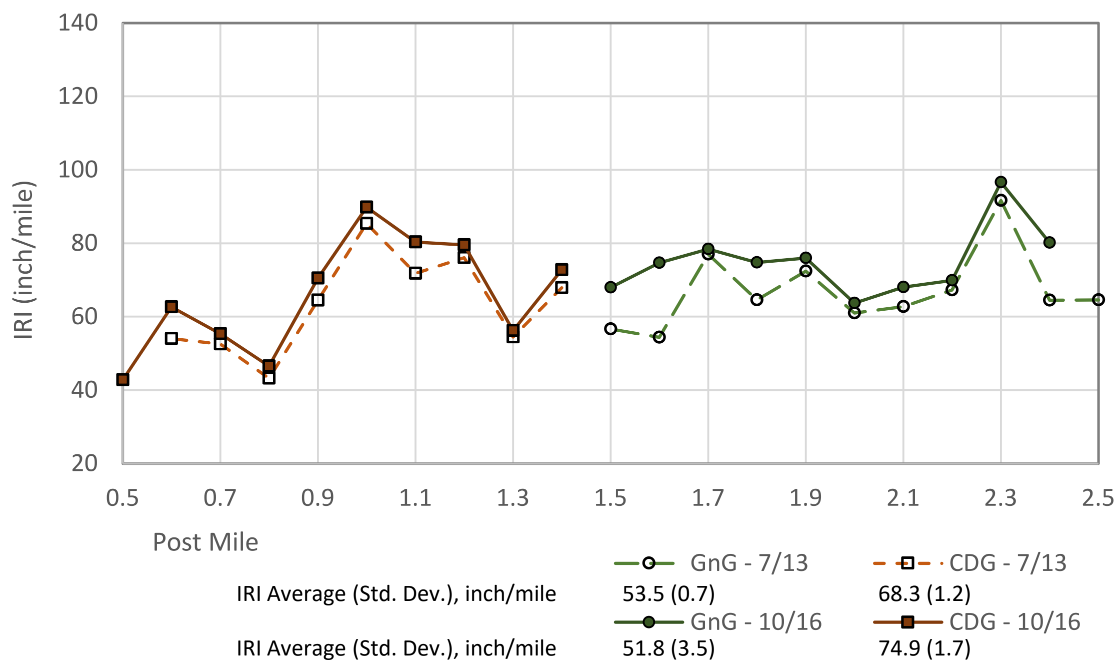

Figure B.10: Yol113S2PM0.5/2.5 IRI data.

B.3 San Diego 5 – PM 35.8/37.9

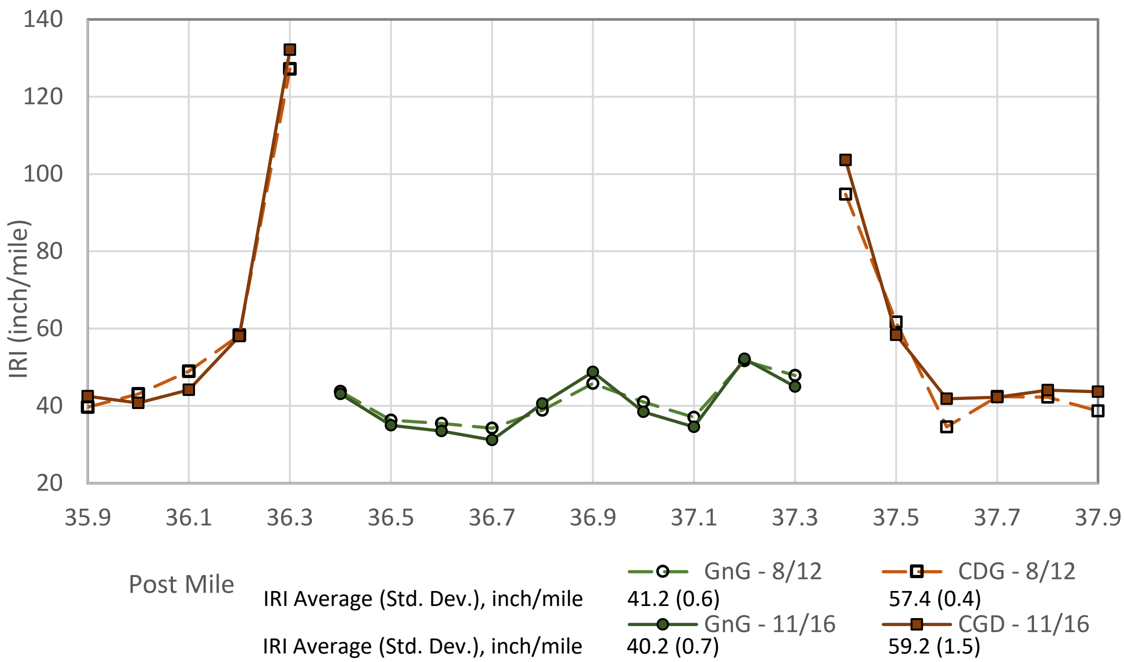

Figure B.11: SD5N1PM35.8/37.9 IRI data.

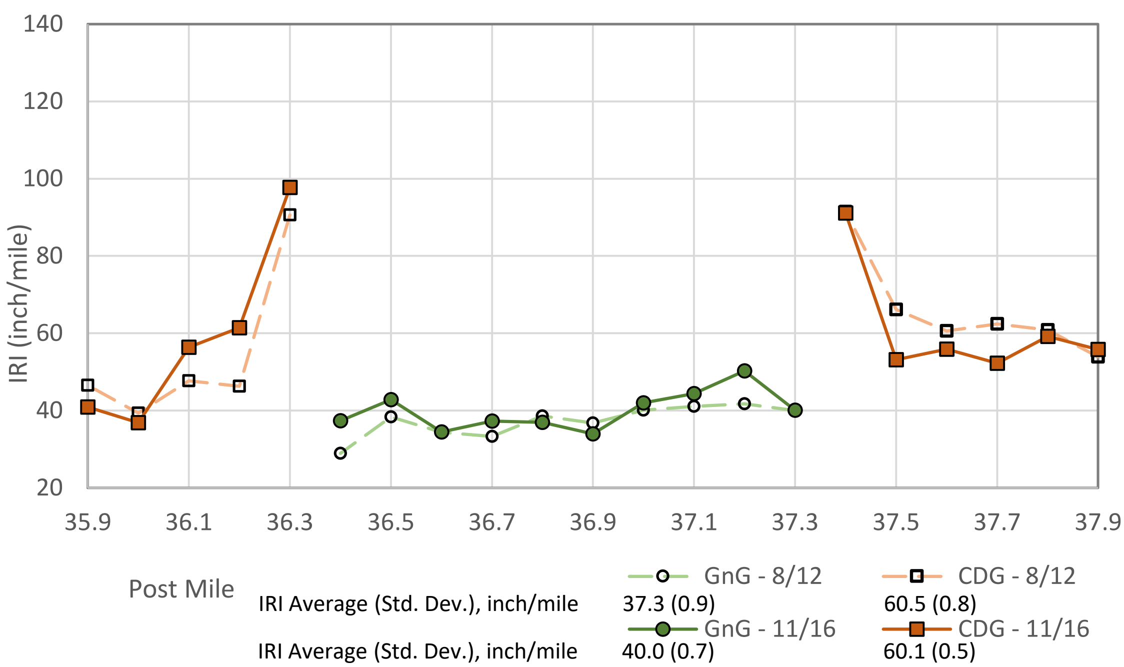

Figure B.12: SD5S1PM35.8/37.9 IRI data.

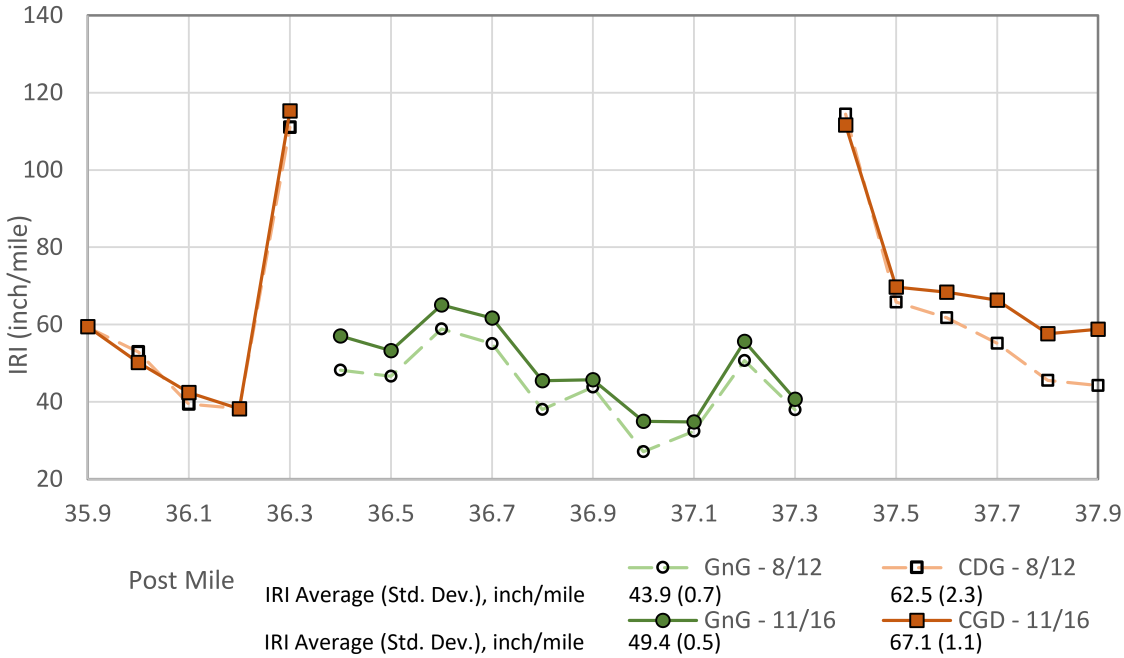

Figure B.13: SD5N2PM35.8/37.9 IRI data.

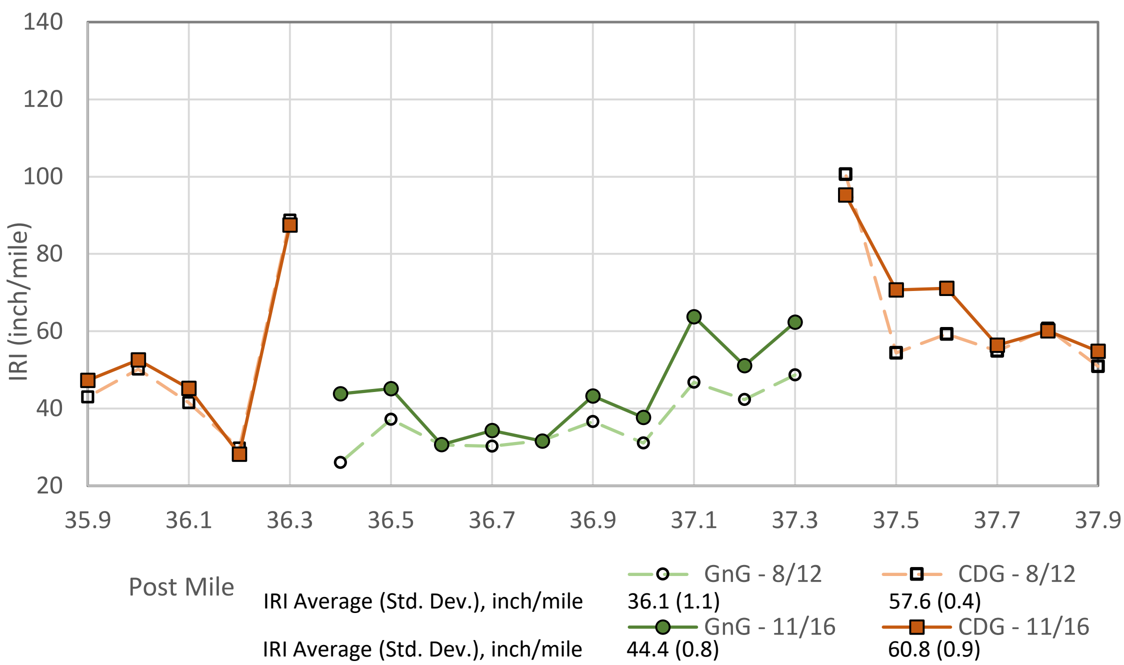

Figure B.14: SD5S2PM35.8/37.9 IRI data.

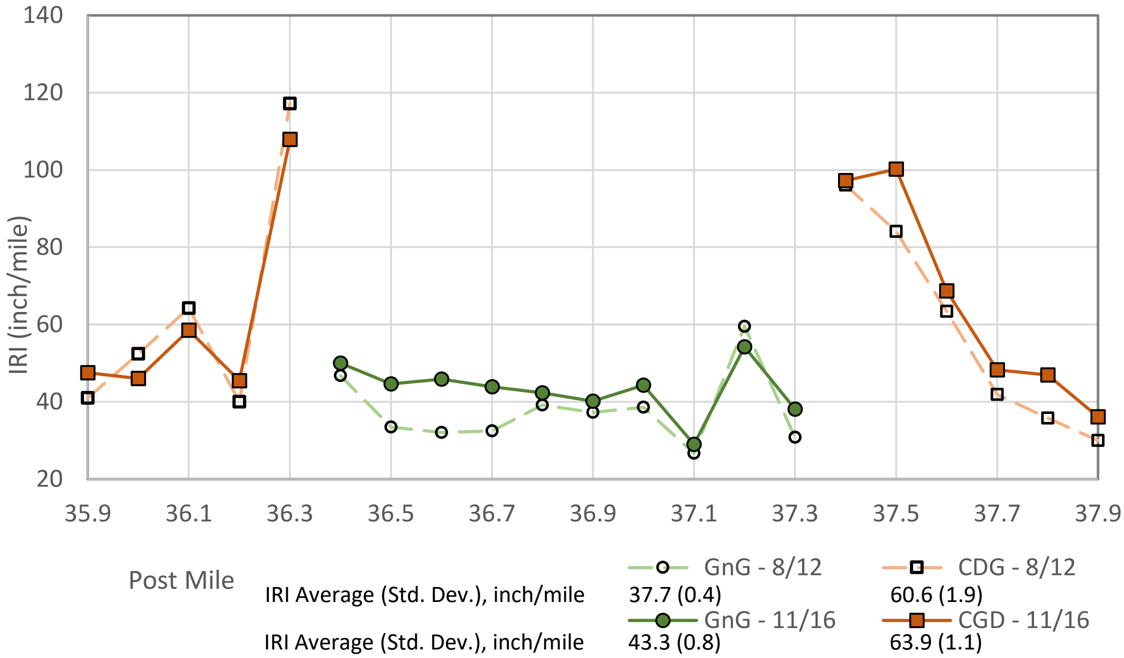

Figure B.15: SD5N3PM35.8/37.9 IRI data.

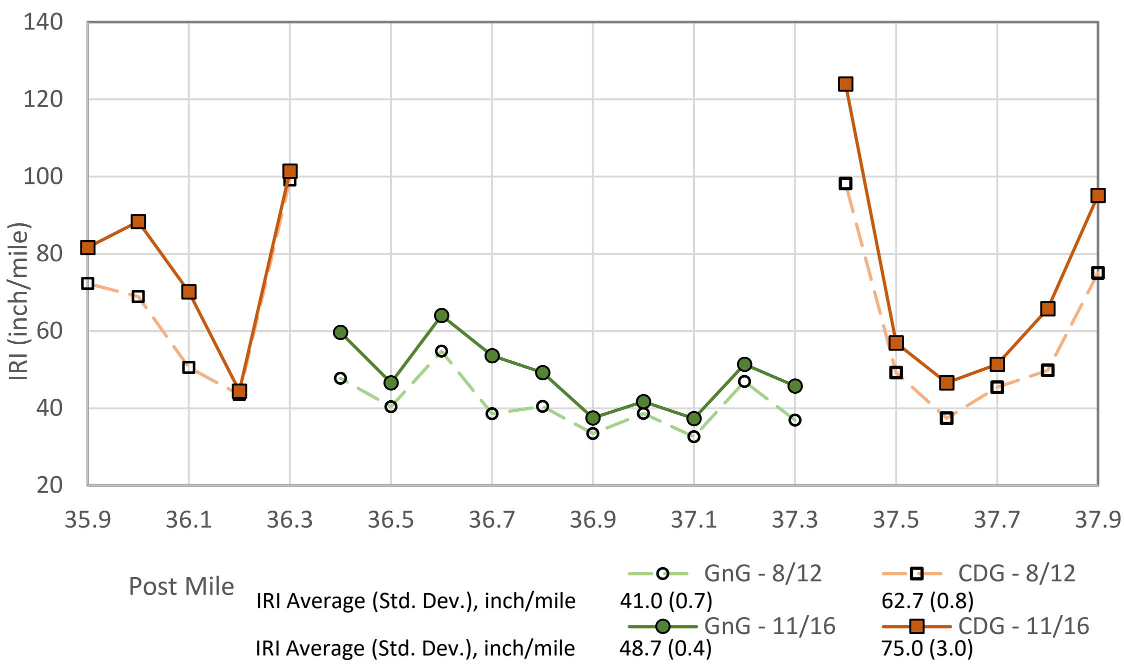

Figure B.16: SD5S3PM35.8/37.9 IRI data.

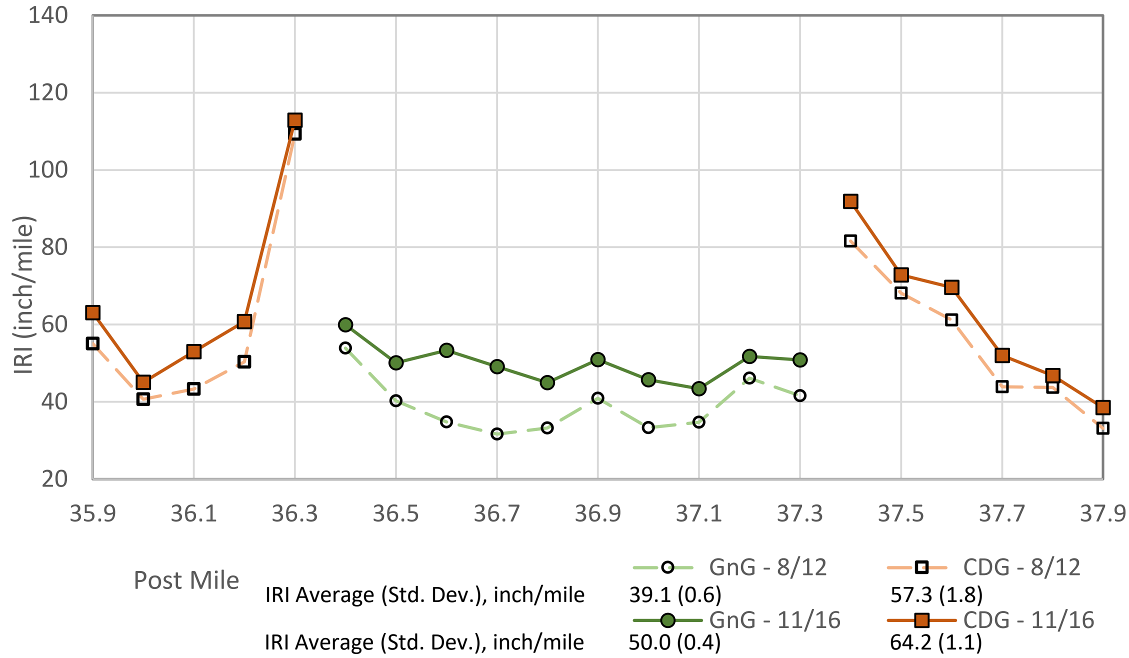

Figure B.17: SD5N4PM35.8/37.9 IRI data.

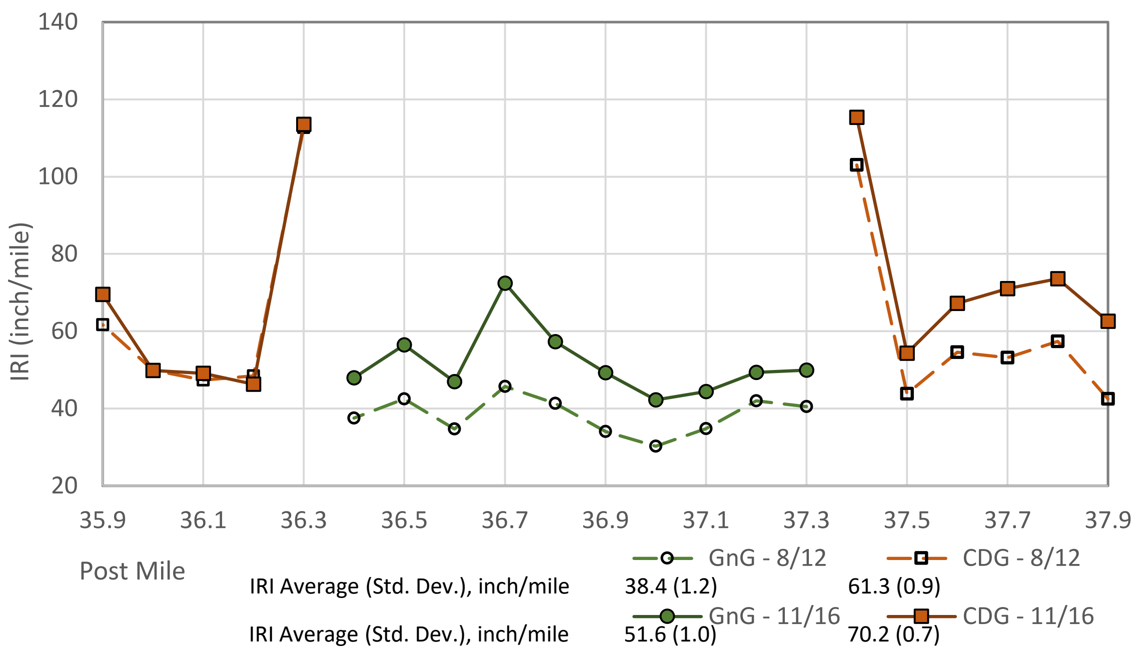

Figure B.18: SD5S4PM35.8/37.9 IRI data.

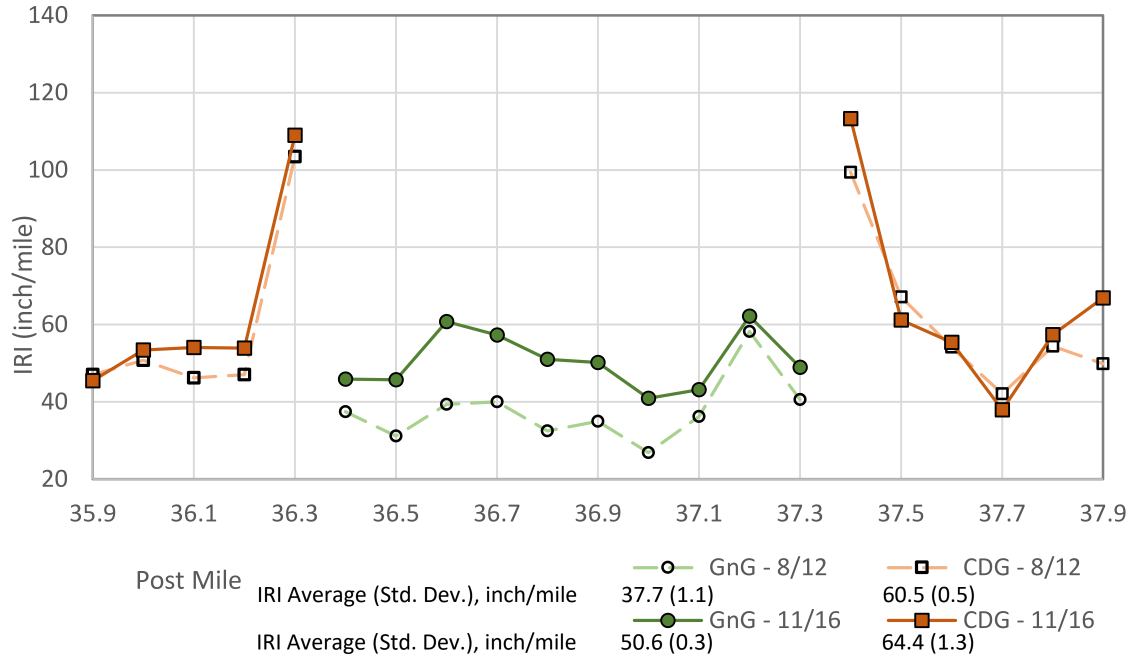

Figure B.19: SD5N5PM35.8/37.9 IRI data.

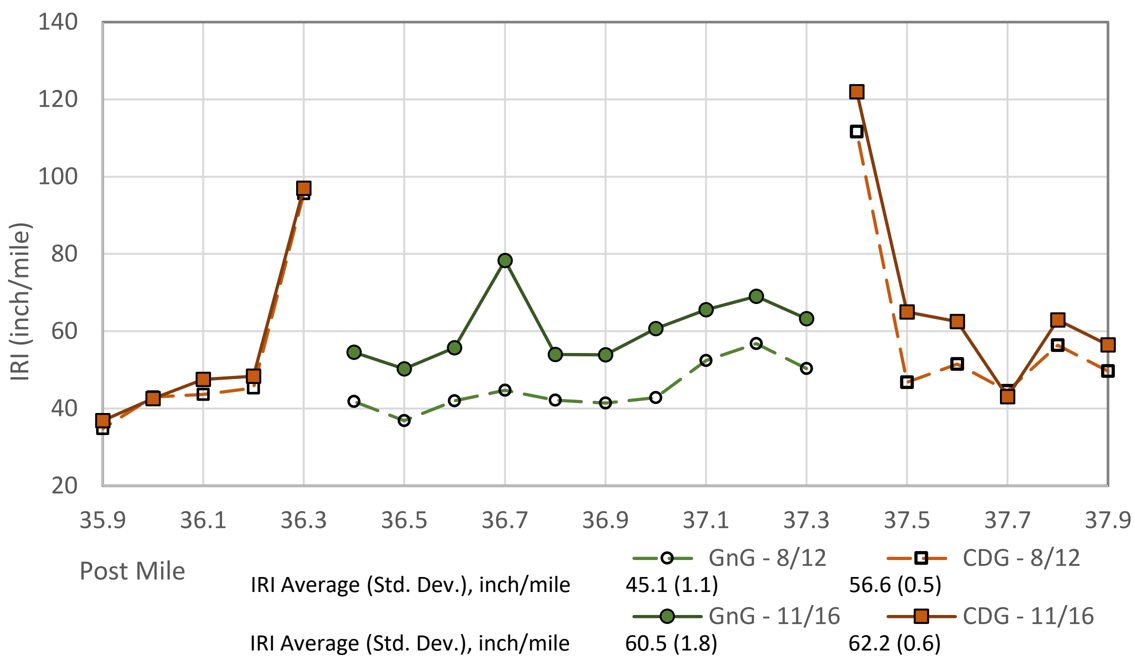

Figure B.20: SD5S5PM35.8/37.9 IRI data.

APPENDIX C   OBSI DATA CORRECTION: TIRE AND AIR DENSITY

Over the years that the on-board sound intensity measurement technology has been used by the UCPRC, there have been improvements to the process of OBSI data collection. As with the research performed in previous years, adjustments to the OBSI data have been made to normalize the results and make them consistent with other OBSI results from prior years. In the past, these adjustments included vehicle speed, sound analyzer, air density, and tire corrections. The vehicle speed is now strictly regulated and the sound analyzer is now standardized, so adjustments are only required for the air density and the test tire.

C.1 Tire Conversion Procedure

The UCPRC monitors the test tires, standard reference test tires (SRTTs), used on the noise test vehicle and replaces the tires between testing phases. The criteria proposed by Donavan and Lodico to determine when the test tire should be replaced are as follows (*1*):

- Tire age should not exceed four years.
- Tire mileage should not exceed 11,000 mi.
- Tire hardness should not exceed a durometer reading of 68 duro.
- Tire tread should be greater than 0.28 in. (7.2 mm).

In November 2011, SRTT#5 was installed on the vehicle for the noise study. The sampling for this project began in 2012 and used SRTT#5 throughout the 2012 and 2013 data collection period. For the data collected in 2016 and 2017, SRTT#6 was installed on the noise vehicle.

While the tires used in both sets of data collection are SRTTs, different SRTTs can influence the data collected. So linear transformation equations are developed using only concrete test sections to adjust the results to the Year 1 SRTT. The sections used to compare the SRTTs are shown in Table C.1. Use of a common reference tire (SRTT#1) allows the eventual comparison of all noise measurements. The conversions were applied by frequency, and the overall sound intensity was calculated from summation of the adjusted spectra values.

Table C.1 also shows the conversion process. Data are collected by both tires on the same section and a linear approximation is used, as shown in Figure C.1. This process is repeated for each frequency: 400 Hz, 500 Hz, 630 Hz, 800 Hz, 1,000 Hz, 1,250 Hz, 1,600 Hz, 2,000 Hz, 2,500 Hz, 3,150 Hz, 4,000 Hz, and 5,000 Hz. Finally, Table C.2 shows the conversion parameters for both the SRTT#5 and SRTT#6 tires to the SRTT#1 tire for each frequency.

Table C.1: Tire Conversion Sections with Data Used in the Conversion Process

Section	SRTT#6	SRTT#1	Difference
Yolo113N2Pm3.0	102.68	102.30	0.38
Yolo113N2Pm6.0	103.42	103.39	0.03
Yolo113S2Pm5.5	103.04	102.59	0.44
Yolo32aE	106.54	107.58	-1.04
Yolo32aW1	105.73	106.56	-0.84
Yolo32aW2	105.15	106.07	-0.92
Yolo505S2Pm13.0	103.58	103.67	-0.09

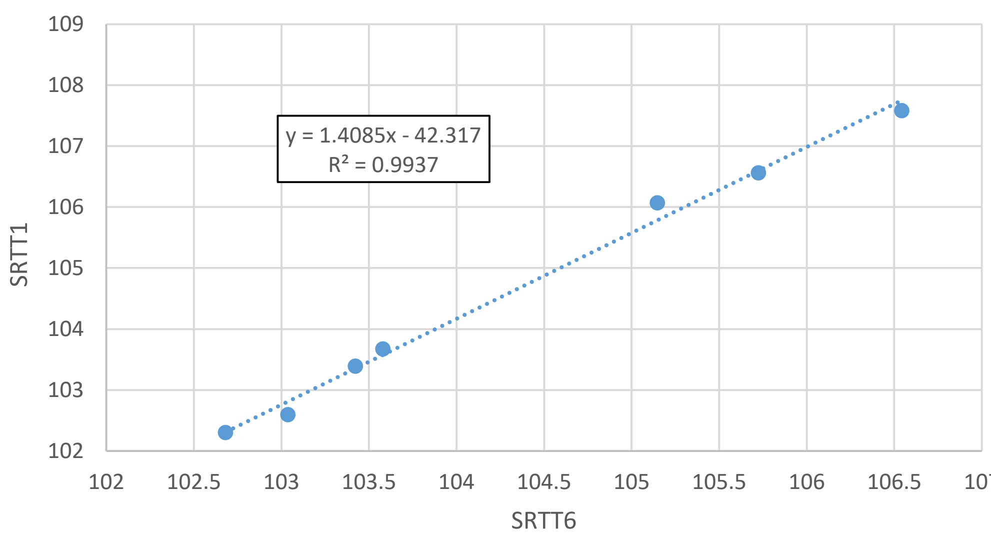

Figure C.1: Tire conversion parameters from compared data.

Table C.2: Tire Conversion Parameters

One-Third Octave Band	SRTT#5 to SRTT#1			SRTT#6 to SRTT#1		
	Slope	Intercept	R2	Slope	Intercept	R2
400	0.694	26.514	0.648	1.193	-17.014	0.944
500	0.902	8.664	0.838	1.208	-18.084	0.993
630	0.914	7.402	0.848	1.154	-13.577	0.996
800	1.087	-8.839	0.909	1.304	-29.783	0.996
1,000	0.886	10.735	0.721	2.132	-112.150	0.939
1,250	0.893	10.446	0.718	1.609	-57.848	0.917
1,600	0.842	15.161	0.886	0.923	8.324	0.855
2,000	1.027	-2.399	0.754	1.024	-0.775	0.884
2,500	0.956	3.742	0.572	1.859	-75.312	0.660
3,150	1.033	-2.929	0.867	0.679	26.710	0.269
4,000	0.757	19.485	0.751	0.669	27.215	0.664
5,000	0.807	14.596	0.656	0.847	12.641	0.786
SumA	1.029	-3.032	0.905	1.408	-42.317	0.994

C.2 Air Density Correction

Air density corrections were applied at each frequency level. The following are the air density correction equations:

Mskg = 3.884266 + 10 ^ ((7.5 x Tc)/(237.7 + Tc))

Mkg = Mskg x Humidity%/100

Tvc = ((1 + 1.609 x Mkg)/(1 + Mkg)) x Tc

Baro = Bmb x exp (-Am/7000)

AirDensity = (Baro x 100)/((Tvc + 273) x 287))

OBSI Correction = 10 x (Log_{10}(ReferenceAirDensity) – Log_{10}(AirDensity))

Where:

Mskg = factor used in the humidity correction,

Tc = temperature (°C),

Mkg = adjustment for humidity,

Baro = adjustment of pressure for altitude,

Bmb = calculation of pressure in mbars,

Am = calculation of altitude in meters,

Tvc = application of the correction to temperature using the humidity adjustment, and

ReferenceAirDensity = 1.21

References

1. Donavan, P., and Lodico, D. 2012. "Variation in On-Board Sound Intensity Levels Created by Different ASTM Standard Reference Test Tires." Presented at Transportation Research Board Annual Meeting Washington, DC, January 22–26, 2012.