STATE OF FLORIDA

2008 RESILIENT MODULUS OF ROADBED SOILS

FACTS & FIGURES

Research Report
FL/DOT/SMO/09-524

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STATE MATERIALS OFFICE

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PAVEMENT MATERIAL SYSTEMS

The Pavement Material Systems provides the Department with the technical expertise to ensure safe and durable pavement systems. This section interacts and partners with other central and district offices, the Federal Highway Administration, pavement industry, and other stakeholders. To support these goals, presented are the Pavement Material System's Mission, Vision, and Value Statements.

Mission
Make Florida's pavements safer, last longer, and perform better.

Vision
The best pavements in the country.

Values
Do it R.I.T.E (Respect, Integrity, Teamwork, and Excellence), Now!

To learn more about our people, functions, and services, we invite you to visit us at:

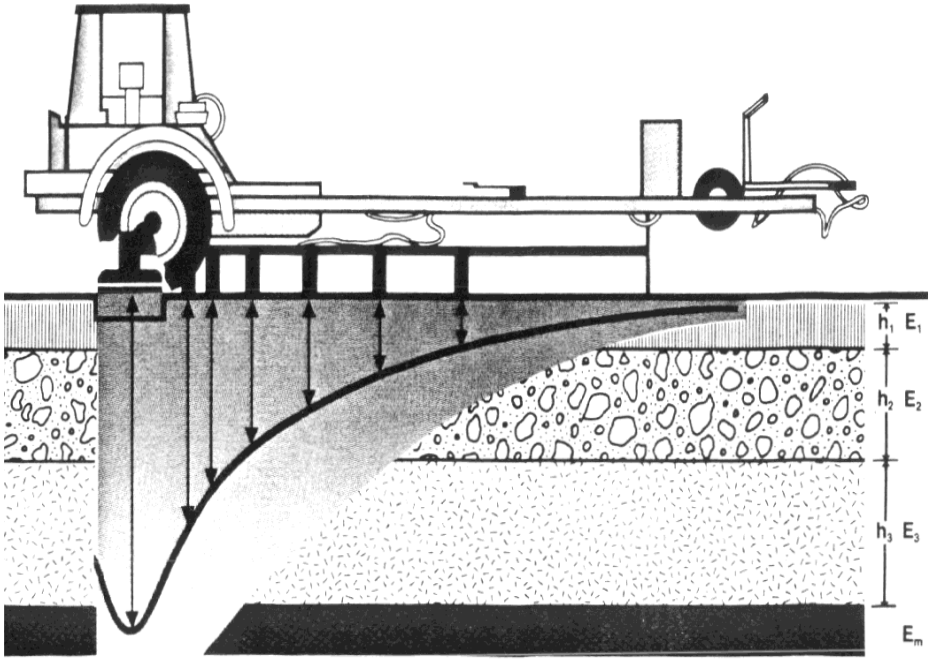
http://www.dot.state.fl.us/statematerialsoffice/pavement/pavementhome.htm

EXECUTIVE SUMMARY

One of the primary functions of the Non-Destructive Testing Group, a unit of the State Materials Office in Gainesville, Florida, is to characterize the in-situ properties of Florida's roadbed materials for pavement design purposes. The basis for such a characterization is the resilient modulus (M_R). The resilient modulus is a measure of the material elastic property recognizing its certain nonlinear characteristics. It is estimated, in our case, in-place from deflection measurements. This information has been critical to the Department's effort to support informed highway planning, as well as policy and decision making. This requires the apportionment and allocation of funds as well as the determination of appropriate cost-effective strategies to rehabilitate and preserve existing highway transportation infrastructure.

This report is intended to provide information regarding our program testing procedures, to report current and past M_R values on a statewide basis, and to identify historical regional M_R trends in the various Districts.

PART I: OVERVIEW



INTRODUCTION

One of the primary functions of the Non-Destructive Testing (NDT) program is to characterize the in-situ properties of the Florida's roadbed (embankment) materials for pavement design purposes. The basis for such a characterization is the resilient modulus (M_R). The resilient modulus is a measure of a material's elastic property recognizing its nonlinear characteristics. It is directly estimated, in our case, in-place using deflection-based techniques.

Deflection-Based Techniques

Due to their speed and ease of operation deflection-based techniques are being widely used in the evaluation of the structural integrity and for estimating the elastic moduli of in-place pavement systems. The deflections can be non-destructively induced and measured using various commercially available devices. These devices are designed based on a variety of loading modes and measuring sensors. The loading modes include static, steady-state vibratory, and impulse loading; while the resulting responses are measured with sensors that include geophones, accelerometers, and linear voltage differential transducers (LVDT).

USE OF DEFLECTION-BASED DEVICES: FLORIDA HISTORICAL PERSPECTIVE

The Department implemented the use of the Falling Weight Deflectometer (FWD) in the early 1980s. It has, however for pavement design purposes, initially specified the use of a Benkelman Beam, and then the use of a vibratory-type device (Dynaflect).

Benkelman Beam

The Benkelman Beam was the first deflection-based device used in Florida for pavement design purposes. It was developed by A.C. Benkelman during the Western Association of State Highway Officials (WASHO) Road Test. It consists of a measurement probe hinged to a three-legged reference beam, as schematically illustrated in Figure 1. The probe is positioned between the rear dual tires of a track, and the rebound deflection is measured by a dial placed on the reference beam when the truck is slowly driven away. Although this method is simple and relatively inexpensive, it is also slow and labor intensive. In addition, the measurements are usually limited to maximum deflections only and are produced under unrealistic load durations. Furthermore, the leveled position of the reference beam may, in some cases, be unduly influenced by the deflection basin.

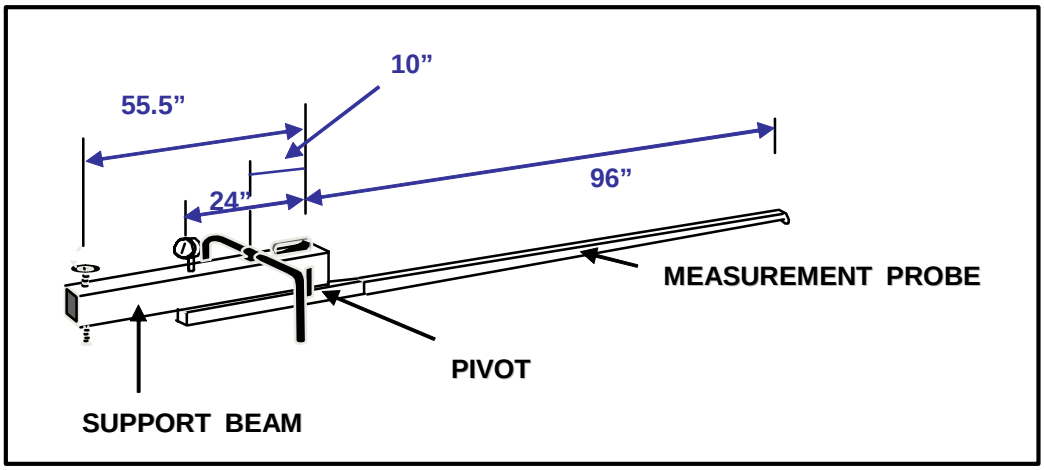


Figure 1. Schematic Illustration of a Benkelman Beam

Dynaflect

In mid-1980s, the Department switched to a steady-state vibratory device, known as Dynaflect. The Dynaflect consists of a relatively lightweight (2,000 lbs.) two-wheel trailer equipped with an automated data acquisition and control system. The deflections are generated by a combination of a sinusoidal dynamic load and the static weight of the trailer. The dynamic loading of a pavement surface is done using two counter-rotating eccentric steel weights. These steel weights, rotating at a constant frequency of eight cycles per second (8 Hz), generate a peak-to-peak dynamic load of approximately 1000 pounds in magnitude. The resulting deflections of a pavement system are measured with geophones. The geophones are electromechanical devices that use a magnetic field to produce an electrical impulse. These geophones are suspended, at set intervals, from the tongue of the trailer.

A primary advantage of the Dynaflect over a static-loading device, such as Benkelman beam, is that a reference frame is not required. In addition, the Dynaflect generates a complete deflection basin at each test location. However, the fixed magnitude and the loading frequency are its major limitations. A photographic illustration of a Dynaflect is given in Figure 2.

Figure 2. Dynaflect Device

Falling Weight Deflectometer

The Falling Weight Deflectometer (FWD) consists of a trailer mounted, falling weight system capable of loading a pavement in a manner that simulates actual wheel loads in both magnitude and duration. An impulse load is generated by dropping a mass from a specified height. The mass is raised hydraulically, then released by an electrical signal and dropped with a buffer system on a 12-inch diameter rigid steel plate. A set of springs between the falling mass and hit bracket mounted above the load cell buffers the impact by decelerating the mass. A thin, neoprene pad rests between the plate and the pavement surface to allow for an even load distribution. When a weight is dropped, an impulse load enters the pavement system creating body and surface waves. The resulting vertical velocity of the pavement surface is picked up through a series of sensors located along the centerline of the trailer. These signals are then used to obtain the maximum deflection from each geophone through analog integrations. A single analog integration of a signal generates the deflection-time trace. The deflection measurements are recorded by the data acquisition system typically located in the tow vehicle. Figure 3 provides a schematic illustration of the FWD loading principle.

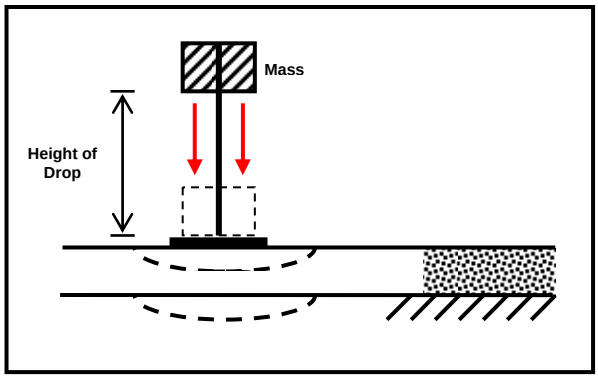


Figure 3. FWD Loading Principle

The use of the Falling Weight Deflectometer (FWD) testing for pavement design and rehabilitation purposes was first introduced by AASHTO in the 1993 Pavement Design Guide. In recent years, the FWD has gained further acceptance among highway agencies because of its versatility, reliability, and ease of use. The FWD loading is believed to better simulate the effects of traffic on pavement structures. Therefore as of March 2001, the Department has implemented the use of FWD for all pavement-related evaluations, including design activities. A photographic illustration of the FWD is shown in Figure 4.

Figure 4. Falling Weight Deflectometer

FLORIDA TESTING PROCEDURE

Deflection Testing

When testing with the FWD for pavement design purposes, two 9-kip load drops are used. However, only the deflection data resulting from the last loadings are considered for roadbed soil characterization. It is generally believed that the deflection data produced under the first impact load may not always be representative of the true pavement response *(2)*. Therefore, the first load is mainly used for the loading plate "seating" purposes. All the deflection data are obtained using the sensor configuration shown in Figure 5.

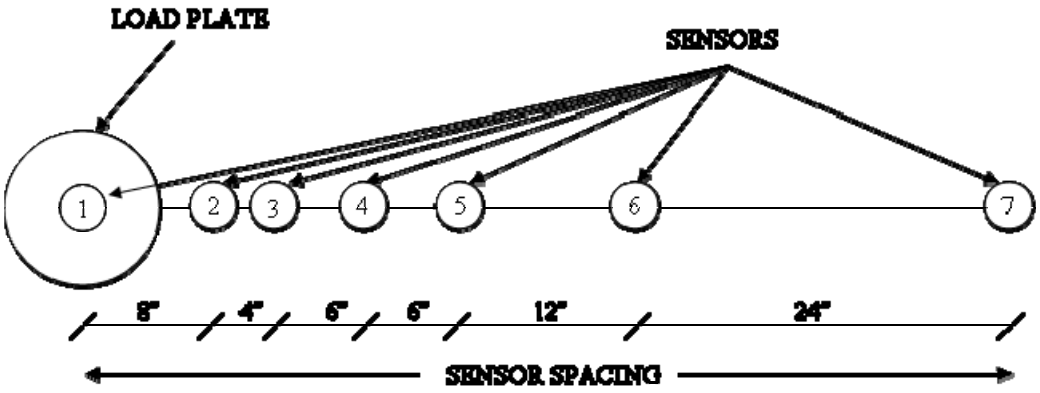


Figure 5. Schematic Illustration of Sensor Configuration

Prediction of In-Place Moduli of Embankment Material

The current procedure for predicting the insitu strength of the embankment material of a pavement system is based on the procedure described in the *AASHTO Guide*

for Design of Pavements Structures calibrated to Florida conditions *(3)*. This method was originally proposed by Ullidtz *(4)*, and is based on Boussinesq's theory on a concentrated load applied on an elastic half-space *(5)*. In this procedure, the modulus of an embankment material is estimated as follows:

$$E_r = 0.24P / d_r \cdot r \quad (2)$$

Where:

E_r = Subgrade modulus, in psi;
P = Applied load, in pounds;
d_r = Deflection measured at a radial distance r, in inches; and
r = Radial distance at which the deflection is measured, in inches.

The *AASHTO Design Guide* suggests the deflection used in the above equation be measured as close as possible to the loading plate and yet be sufficiently far from the load. This is suggested to satisfy the assumption that, at points sufficiently distant from the load, the deflections measured at the pavement surface are mainly due to the embankment deformation, and are also independent of the load plate size. Florida's previous experience with non-destructive deflection testing has shown that the pavement deflections measured at 36 inches away from the load are appropriate for the determination of the embankment moduli. Therefore, only the pavement deflections measured at 36 inches (r = 36 inches in equation 2) away from the load are considered for design purposes in the Florida procedure. Furthermore, within a project limits, the resilient modulus (Mr) value is reported based on the mean deflection plus two standard deviations (d_r = mean deflection + 2 σ).

HISTORICAL FWD DATA

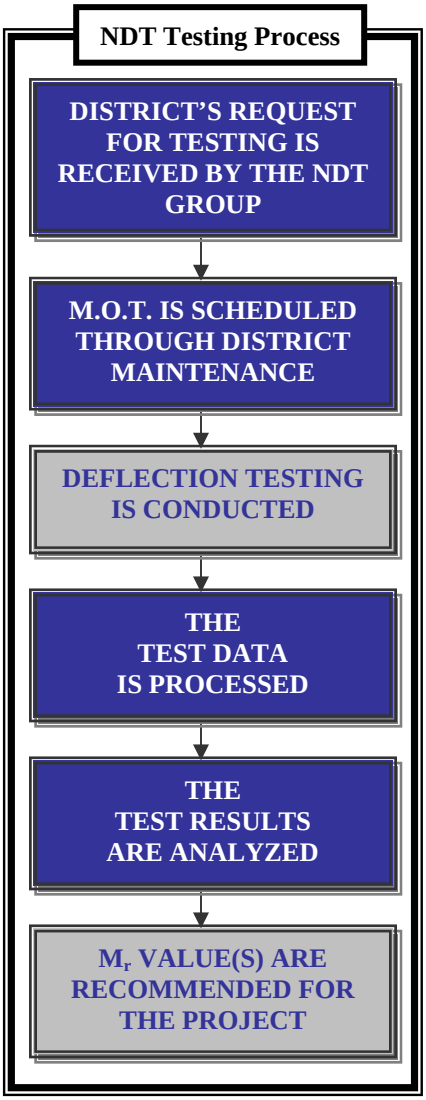
The historical FWD data can be found on the State Materials Office's website at:

http://databases.sm.dot.state.fl.us/fwddata.htm

PROJECT TESTING REQUESTS

To request a project to be tested, simply contact the following District FWD coordinators:

District	Name	E-mail
1	Debra Childs	Debra.childs@dot.state.fl.us
2	Chad Townsend	Chad.townsend@dot.state.fl.us
3	Samuel Weede	Samuel.weede@dot.state.fl.us
4	Brent Lee-Shue-Ling	Brent.Lee-Shue-Ling@dot.state.fl.us
5	Timothy Keefe	Timothy.keefe@dot.state.fl.us
6	Cathy Margoshes	Cathy.margoshes@dot.state.fl.us
7	Mary Sheets	Mary.sheets@dot.state.fl.us
Turnpike	William Cook	William.cook@dot.state.fl.us



Include the following information within the body of the request:

1.) Roadway Id (e.g. SR 91, 91470000, FL Turnpike)
2.) County Name (e.g. Okeechobee)
3.) Project Limits (e.g. MP 181.7 to MP 188.9)
4.) Exceptional Needs (e.g. Extend testing 1000 ft past Begin/End segment limits, vibration analysis desired.)
5.) Project Location Map
6.) Recommended Due Date
7.) MOT, Traffic Restrictions

After the District FWD coordinators have gathered the information needed for the requested projects, they will submit the request to the SMO's NDT group. The NDT group will then review the submitted requests and schedule Maintenance of Traffic (MOT) with District Maintenance Offices for deflection testing. The flow chart to the right details the project testing process.

For coordination purposes, it is best to provide the State Materials Office with as much time as possible by submitting any testing requests immediately after the work program has been updated and the project schedules are set. In order to ensure that all requests may be dealt with in a timely and efficient manner, a minimum of 6 months is required by the State Materials Office for testing. For further information on SMO's FWD deflection testing process, contact:

Charles Holzschuher, Nondestructive Testing
charles.holzschuher@dot.state.fl.us
Fax: (352) 955-6345

Field Testing Requirements

Generally testing is only conducted on 2-lane projects greater than 1 mile long, or on multi-lane projects greater than 0.5 mile long.

Testing frequency for 2-lane projects is conducted at 28 tests / mile in one direction. For multi-lane projects testing is conducted at 14 tests / mile / each direction.

IDENTIFICATION OF VIBRATION SENSITIVE WORK ZONES

Based on the findings of a recent research project, FDOT developed a methodology for identifying vibration-sensitive portions of resurfacing projects during routine pre-construction testing that does not require a detailed knowledge of the layering of the pavement structure or the geology of the surrounding site (6, 7). When the State Materials Office personnel is informed that a project is potentially vibration-sensitive, the FWD operator will be alerted to record the full FWD displacement time histories on each FWD test performed during pre-design testing. The time history data will then be processed to develop upper bound predictor of the ground motion at the site. By knowing or assuming a frequency for the vibratory roller to be used during construction, the peak particle velocity can be used to identify locations along a given project where vibratory compaction is not recommended. The analysis procedure is outlined in Figure 6.

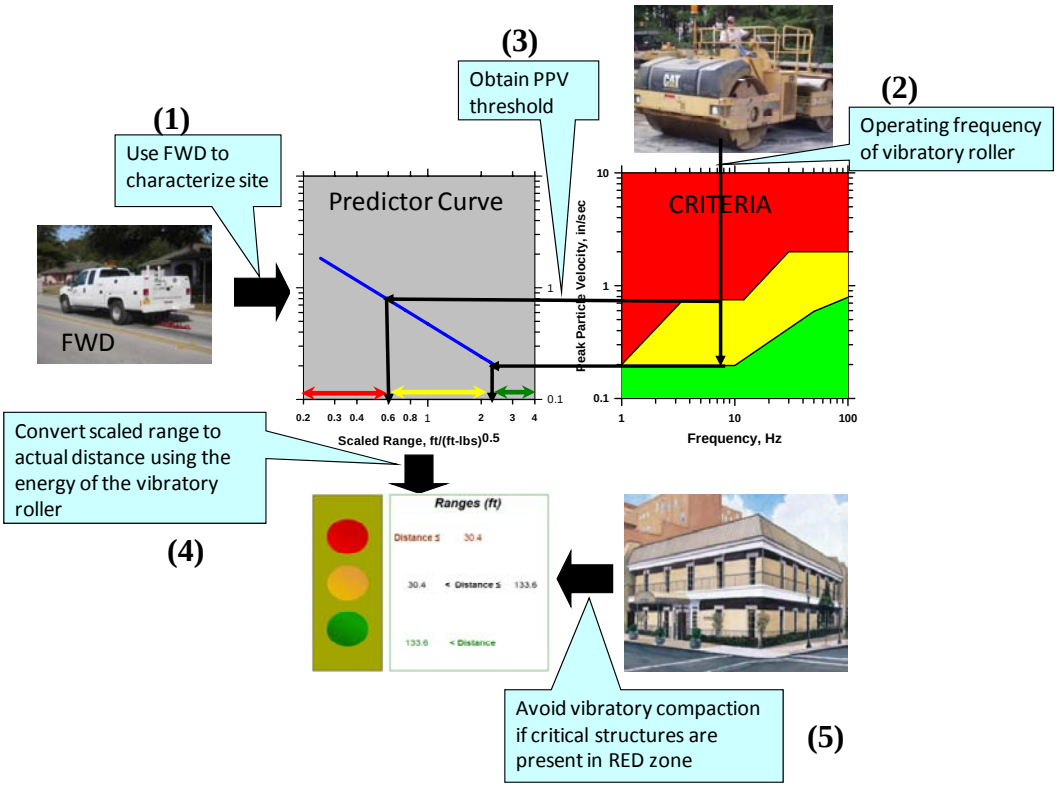


Figure 6. Vibration Analysis Procedures (6, 7)

The outcome of the analysis is a brief report that provides the limits for the "Red", "Yellow" and "Green" zones defined as:

- RED zone: designates a region where the vibratory compaction may cause damage to nearby structures.
- YELLOW zone: designates a region where the vibratory compaction may cause human annoyance, but damage to buildings is unlikely.
- GREEN zone: designates the region where the vibratory compaction may or may not be noticeable, and human annoyance is unlikely.

An example of the project-specific vibration report is shown in Figure 7. If a sensitive structure is found within the limits of the "Red" zone, it is recommended that use of vibratory rollers for compaction of pavement layers be avoided and other means of compacting be considered to prevent major or minor damages in the structure, especially in urban areas.

FWD time histories can be easily collected while the typical deflection testing is performed for determining the resilient modulus values and no other information is necessary to perform the vibration analysis. To submit a request for the vibration report, simply inform the District FWD coordinators that the vibration report is needed when submitting the request for FWD testing. Then, the Nondestructive Testing Unit will provide the vibration report with the resilient modulus recommendations.

Non-Destructive Testing
Vibratory Compaction Criteria Report

PROJECT INFORMATION **DATE** 02/16/07

FIN:	239266-3
COUNTY:	Orange
SECTION ID:	75080
STATE ROAD NUMBER:	15
DIRECTION:	Northbound
COMMENTS:	This is an example problem.

ROLLER INFORMATION

☑ ***Default roller was used.***

Default roller was not used.

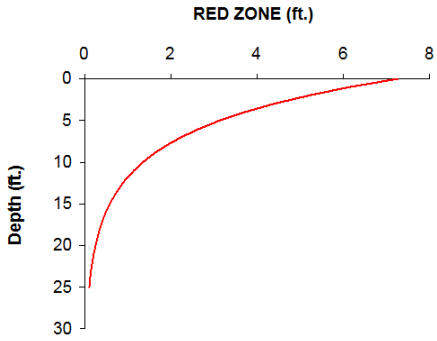
LOAD (lbf):	44,120
AMPLITUDE (in):	0.035
FREQUENCY (Hz):	42
DRUM DIAMETER (in):	59

VIBRATION CRITERIA: SURFACE STRUCTURES

RED ZONE (ft):	Distance (ft) ≤	7.3		
YELLOW ZONE (ft):	7.3	< Distance (ft) ≤	40.8	
GREEN ZONE (ft):	Distance (ft) >	40.8		

Conditions in the RED ZONE should be avoided to prevent possible architectural or structural damage to buildings. Conditions in the YELLOW ZONE are acceptable; however, the department should be prepared to receive complaints from persons who may be annoyed by the vibration. Operations in the GREEN ZONE should incur few, if any, complaints from the public.

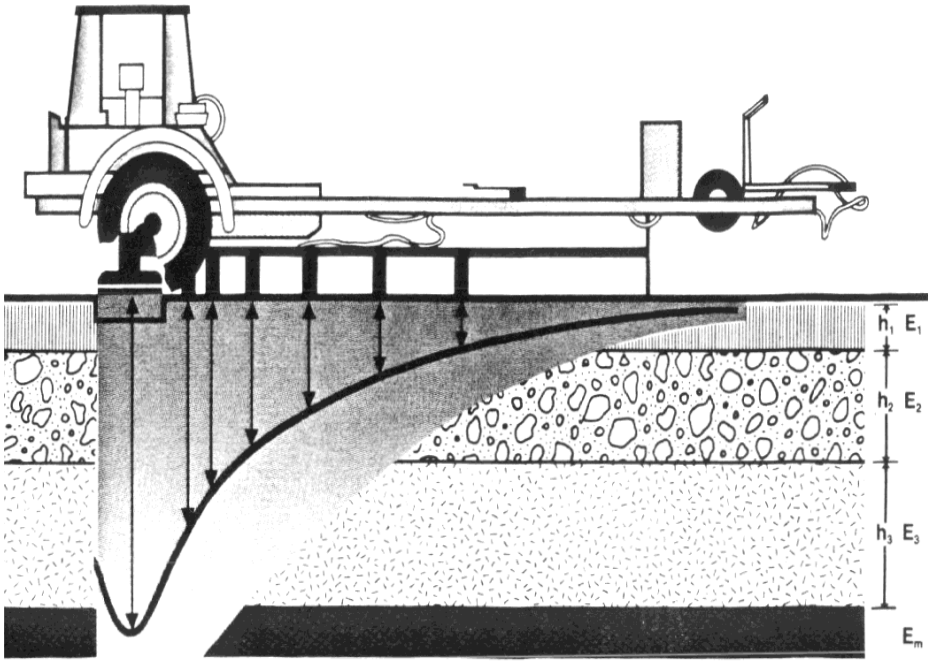
VIBRATION CRITERIA: BURIED STRUCTURES



For fragile buried structures, the plot to the left shows the RED ZONE as a function of depth. Enter the plot at the depth of the buried structure and estimate the RED ZONE from the curve. Vibratory compaction is not recommended within a distance equal to the RED ZONE from the buried structure.

Figure 7. Sample Vibration Report

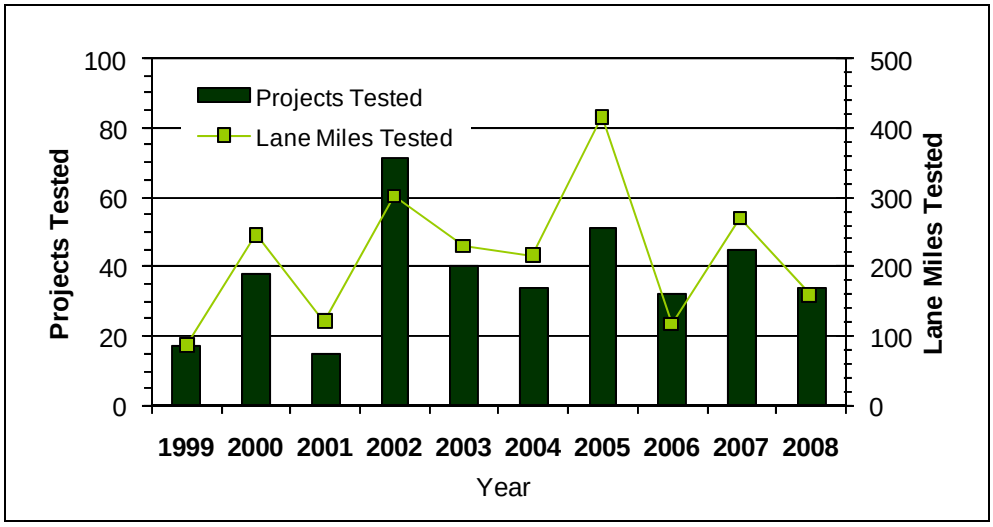
PART II: FACTS & FIGURES[1]

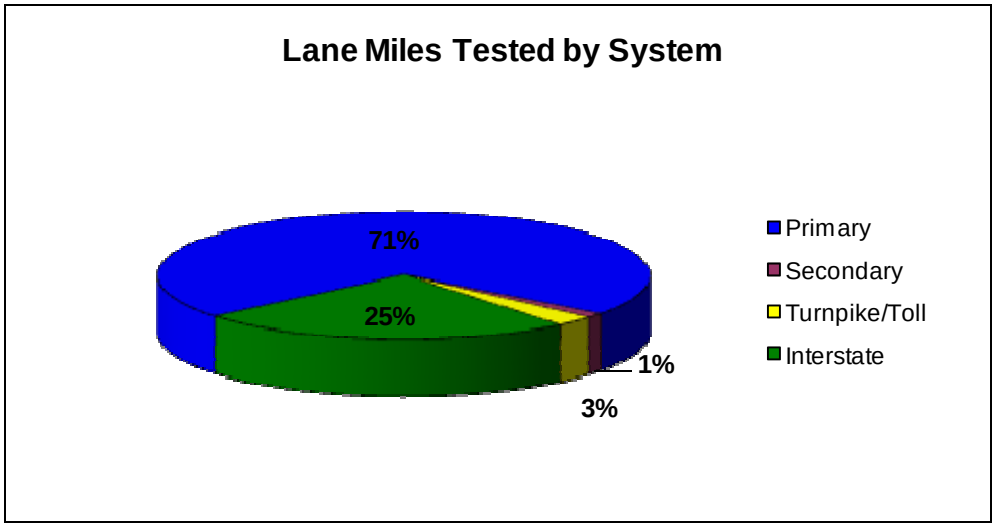


[1] Project resilient modulus values presented are the lowest values recommended for each project. Some projects may have multiple resilient modulus values.

DISTRICT 1 TEN YEAR PRODUCTION SUMMARY

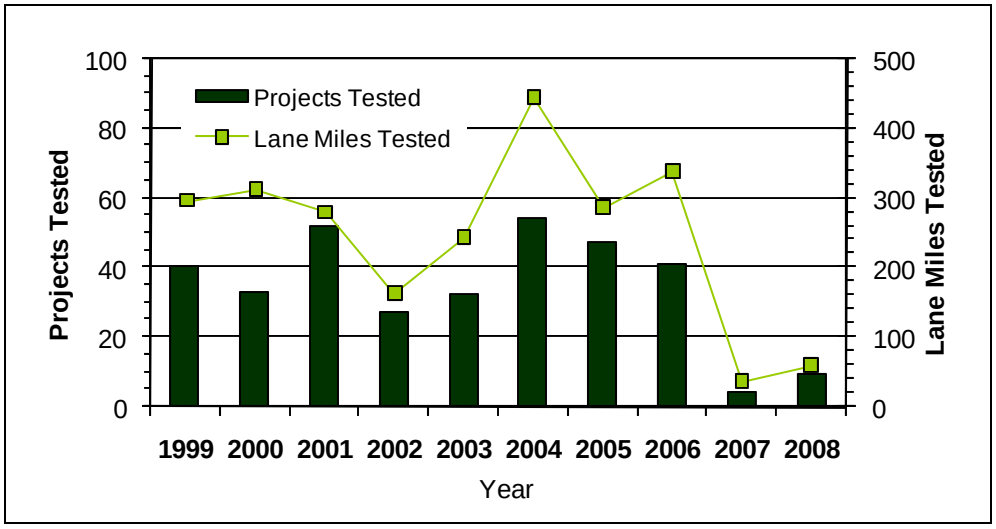
	Primary		Secondary		Turnpike/Toll		Interstate		All Systems	
	Projects	Lane Miles	Projects	Lane Miles	Projects	Lane Miles	Projects	Lane Miles	Projects	Lane Miles
1999	15	74.338	2	11.510	0	0.000	0	0.000	17	85.848
2000	33	201.881	0	0.000	0	0.000	5	44.240	38	246.121
2001	11	57.697	0	0.000	1	14.000	3	48.970	15	120.667
2002	68	243.512	0	0.000	0	0.000	3	58.212	71	301.724
2003	32	154.144	0	0.000	0	0.000	8	74.998	40	229.142
2004	31	174.207	1	3.711	0	0.000	2	38.752	34	216.670
2005	41	258.518	0	0.000	1	42.842	9	115.278	51	416.638
2006	28	42.635	0	0.000	0	0.000	4	74.100	32	116.735
2007	37	205.964	0	0.000	0	0.000	8	63.750	45	269.714
2008	31	132.085	1	9.944	0	0.000	2	17.402	34	159.431
Total	327	1544.981	4	25.165	2	56.842	44	535.702	377	2162.690

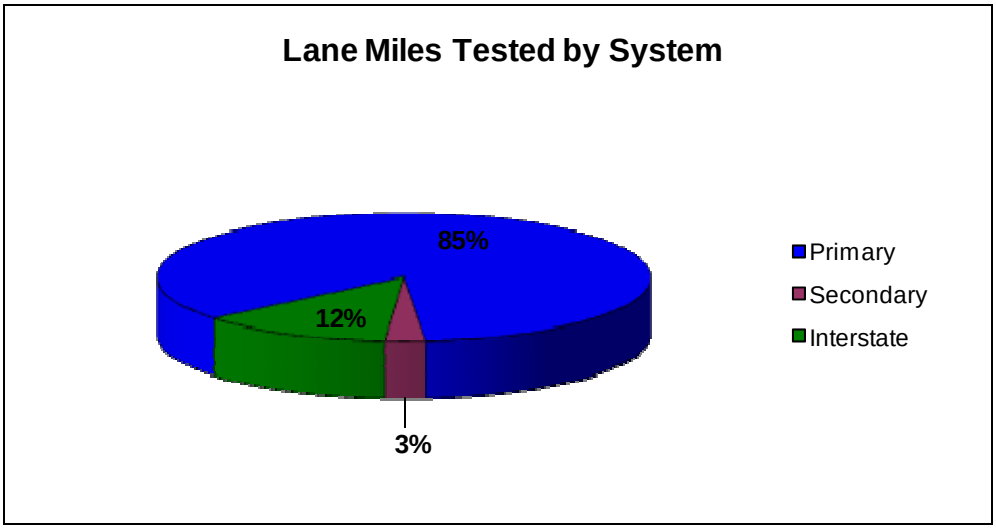




DISTRICT 2 TEN YEAR PRODUCTION SUMMARY

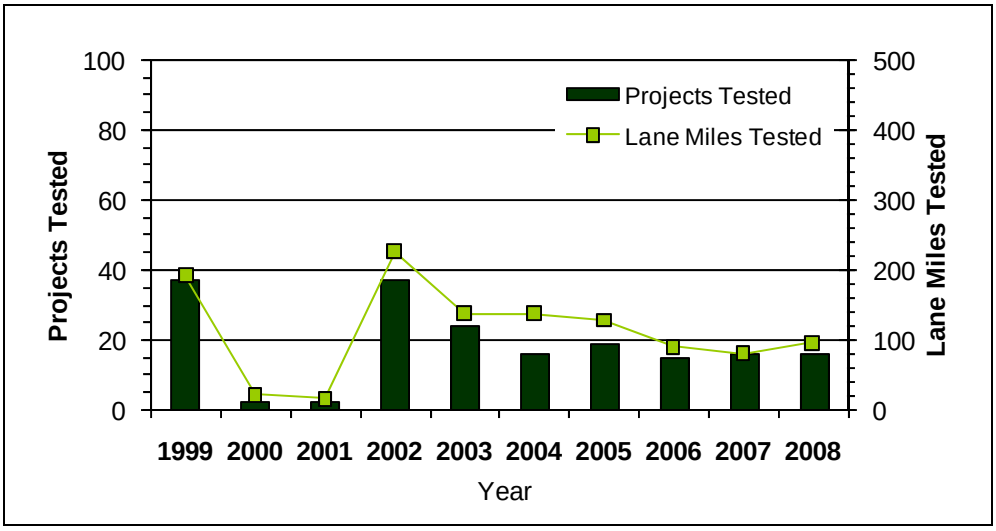
	Primary		Secondary		Turnpike/Toll		Interstate		All Systems	
	Projects	Lane Miles	Projects	Lane Miles	Projects	Lane Miles	Projects	Lane Miles	Projects	Lane Miles
1999	40	296.747	0	0.000	0	0.000	0	0.000	40	296.747
2000	30	254.138	1	6.156	0	0.000	2	49.812	33	313.106
2001	49	243.803	1	6.034	0	0.000	2	27.224	52	280.061
2002	26	153.046	0	0.000	0	0.000	1	8.734	27	162.780
2003	27	166.176	2	8.105	0	0.000	3	65.040	32	244.321
2004	47	332.541	0	0.000	0	0.000	7	105.366	54	444.907
2005	40	250.477	6	27.071	0	0.000	1	1.420	47	285.968
2006	34	292.598	3	19.062	0	0.000	4	20.554	41	339.214
2007	4	37.273	0	0.000	0	0.000	0	0.000	4	37.273
2008	7	30.746	0	0.000	0	0.000	2	28.060	9	60.806
Total	304	2057.545	13	66.428	0	0.000	22	306.210	339	2465.183

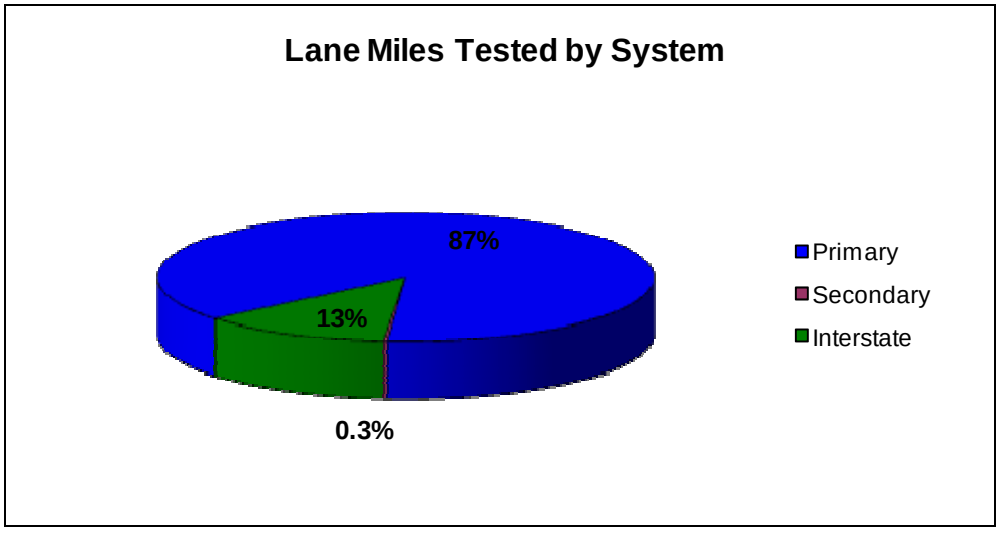




DISTRICT 3 TEN YEAR PRODUCTION SUMMARY

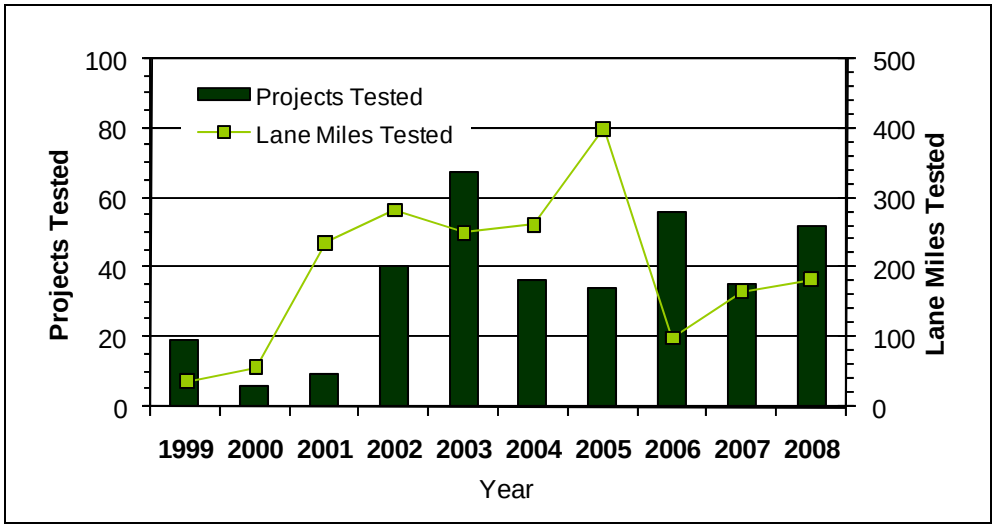
	Primary		Secondary		Turnpike/Toll		Interstate		All Systems	
	Projects	**Lane Miles**	**Projects**	**Lane Miles**	**Projects**	**Lane Miles**	**Projects**	**Lane Miles**	**Projects**	**Lane Miles**
1999	31	146.909	0	0.000	0	0.000	6	37.440	37	190.349
2000	2	20.376	0	0.000	0	0.000	0	0.000	2	20.376
2001	2	15.036	0	0.000	0	0.000	0	0.000	2	15.036
2002	37	225.450	0	0.000	0	0.000	0	0.000	37	225.450
2003	23	116.972	0	0.000	0	0.000	1	18.332	24	136.304
2004	13	87.816	1	2.857	0	0.000	2	42.910	16	136.583
2005	17	101.852	0	0.000	0	0.000	2	23.222	19	127.074
2006	14	73.388	0	0.000	0	0.000	1	15.158	15	89.546
2007	16	79.768	0	0.000	0	0.000	0	0.000	16	79.768
2008	16	94.629	0	0.000	0	0.000	0	0.000	16	94.629
Total	171	962.196	1	2.857	0	0.000	12	137.062	184	1115.115

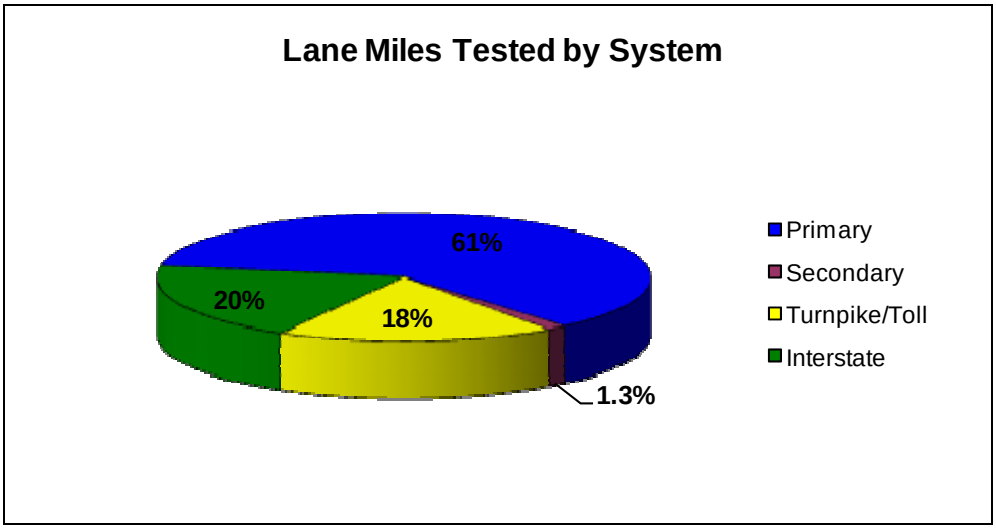




DISTRICT 4 TEN YEAR PRODUCTION SUMMARY

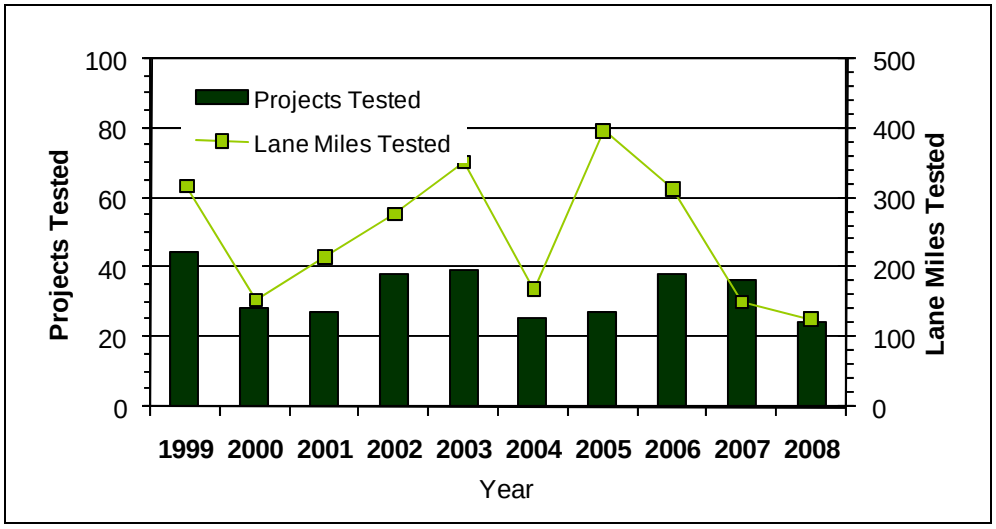
	Primary		Secondary		Turnpike/Toll		Interstate		All Systems	
	Projects	Lane Miles	Projects	Lane Miles	Projects	Lane Miles	Projects	Lane Miles	Projects	Lane Miles
1999	5	19.405	0	0.000	1	16.938	0	0.000	19	37.343
2000	6	20.856	0	0.000	0	0.000	3	33.492	6	57.348
2001	28	123.333	0	0.000	5	32.678	7	69.074	9	237.085
2002	58	207.308	1	0.997	2	26.000	6	40.722	40	284.027
2003	28	119.843	0	0.000	3	62.200	5	60.570	67	250.613
2004	29	157.283	0	0.000	5	99.708	0	0.000	36	261.991
2005	50	249.376	1	0.864	2	92.252	3	52.102	34	400.594
2006	9	27.138	2	2.992	0	0.000	5	62.794	56	99.924
2007	28	106.443	3	8.520	1	10.800	3	34.620	35	167.383
2008	48	138.321	2	12.469	1	7.800	1	21.198	52	183.788
Total	289	1169.306	9	25.842	20	348.376	33	374.572	354	1980.096

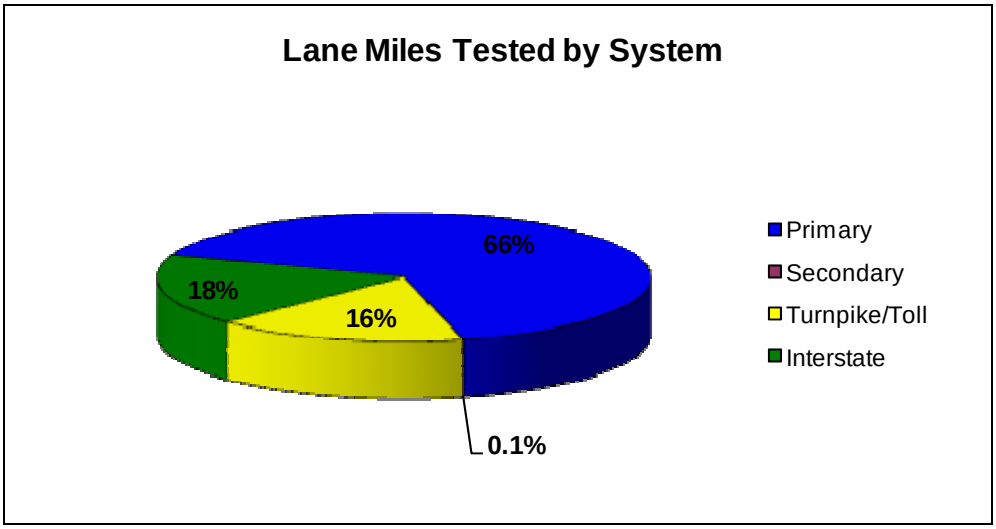




DISTRICT 5 TEN YEAR PRODUCTION SUMMARY

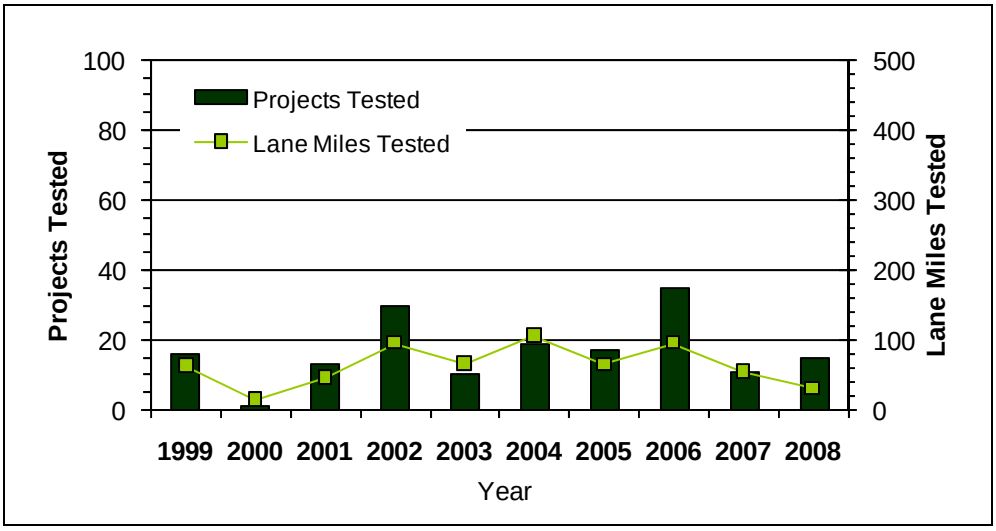
	Primary		Secondary		Turnpike/Toll		Interstate		All Systems	
	Projects	Lane Miles	Projects	Lane Miles	Projects	Lane Miles	Projects	Lane Miles	Projects	Lane Miles
1999	32	218.163	0	0.000	7	36.439	5	51.556	44	318.158
2000	18	92.273	1	1.754	5	20.160	4	30.416	28	154.603
2001	20	146.606	0	0.000	3	10.960	4	52.092	27	216.658
2002	35	251.763	0	0.000	3	23.568	0	0.000	38	278.331
2003	28	155.280	1	0.554	4	73.914	6	111.872	39	352.620
2004	24	140.590	0	0.000	0	0.000	1	27.890	25	169.480
2005	23	193.776	0	0.000	2	167.434	2	32.714	27	397.924
2006	30	169.53	0	0.000	1	21.340	7	115.096	38	313.966
2007	35	138.15	0	0.000	0	0.000	1	12.316	36	151.466
2008	18	77.386	0	0.000	6	43.012	0	0.000	24	126.398
Total	263	1583.517	2	2.308	31	396.827	30	433.952	326	2479.604

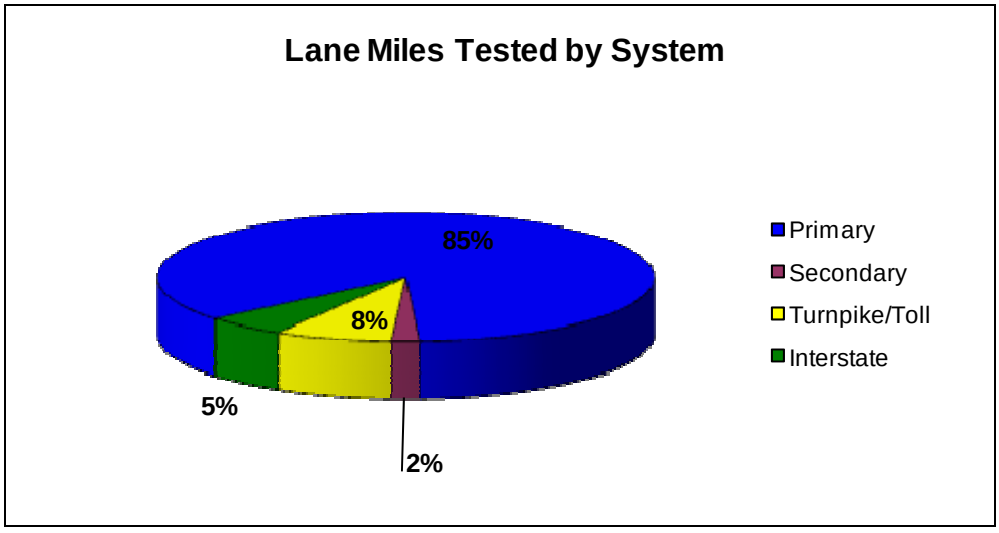




DISTRICT 6 TEN YEAR PRODUCTION SUMMARY

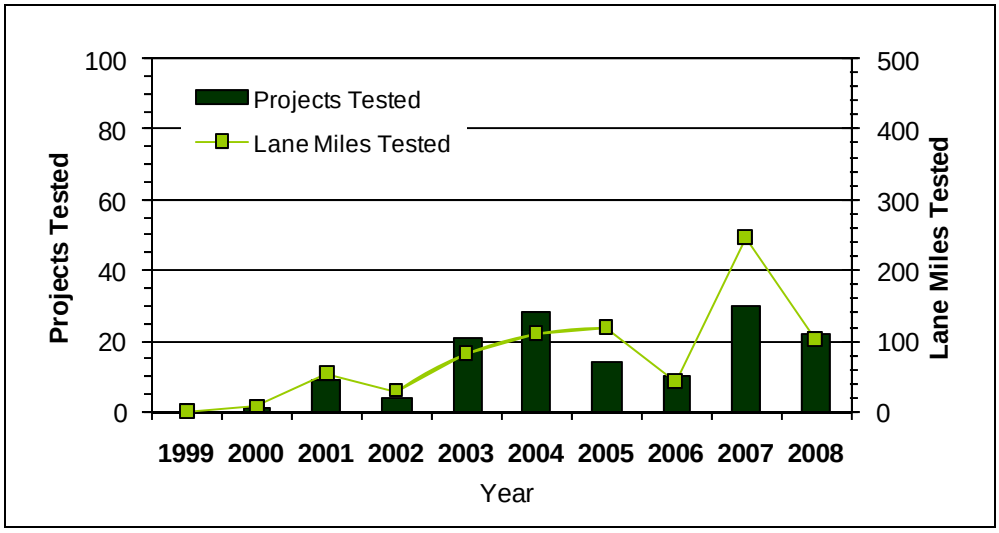
	Primary		Secondary		Turnpike/Toll		Interstate		All Systems	
	Projects	Lane Miles	Projects	Lane Miles	Projects	Lane Miles	Projects	Lane Miles	Projects	Lane Miles
1999	16	62.036	0	0.000	0	0.000	0	0.000	16	62.036
2000	1	12.715	0	0.000	0	0.000	0	0.000	1	12.715
2001	12	38.662	0	0.000	0	0.000	1	4.414	13	44.076
2002	29	82.816	1	11.065	0	0.000	0	0.000	30	94.881
2003	8	53.317	0	0.000	0	0.000	2	8.806	10	64.123
2004	18	64.316	0	0.000	1	40.150	0	0.000	19	105.466
2005	16	51.723	0	0.000	0	0.000	1	10.844	17	63.567
2006	34	91.219	0	0.000	0	0.000	1	2.484	35	94.703
2007	8	37.262	0	0.000	1	6.684	2	6.190	11	53.136
2008	15	29.5	0	0.000	0	0.000	0	0.000	15	29.500
Total	157	523.566	1	11.065	2	46.834	7	32.738	167	624.203

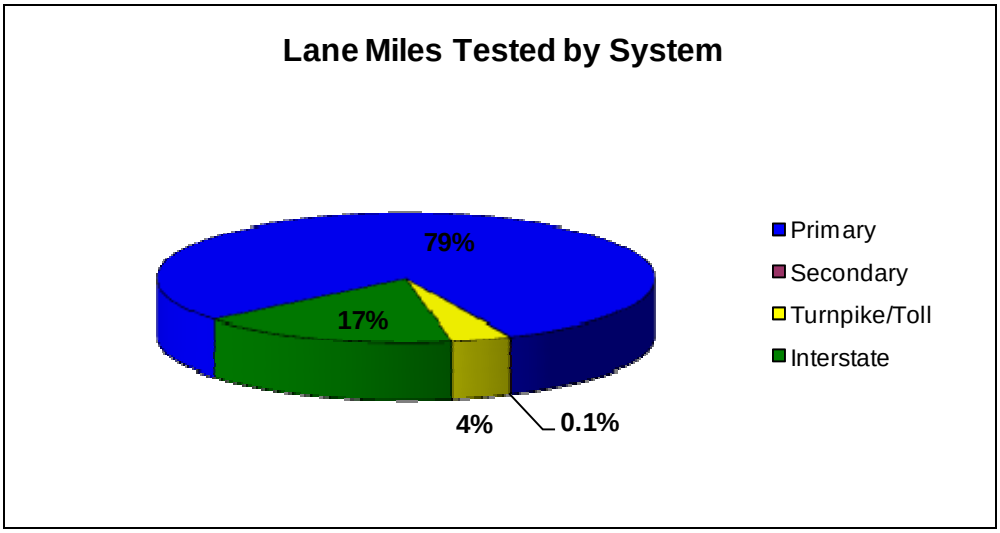




DISTRICT 7 TEN YEAR PRODUCTION SUMMARY

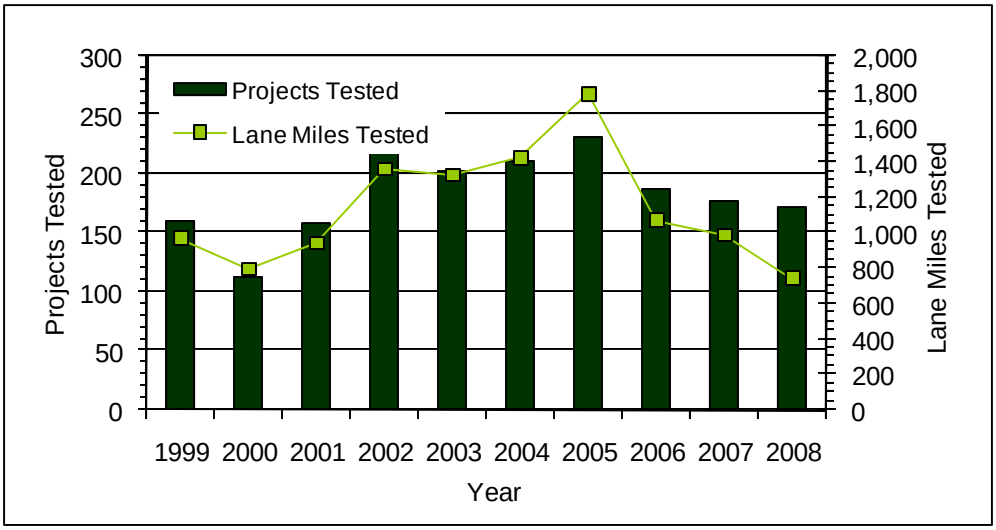
	Primary		Secondary		Turnpike/Toll		Interstate		All Systems	
	Projects	Lane Miles	Projects	Lane Miles	Projects	Lane Miles	Projects	Lane Miles	Projects	Lane Miles
1999	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000
2000	1	7.746	0	0.000	0	0.000	0	0.000	1	7.746
2001	7	33.069	0	0.000	0	0.000	2	19.464	9	54.533
2002	3	9.433	0	0.000	0	0.000	1	19.232	4	29.665
2003	19	60.655	0	0.000	0	0.000	2	18.898	21	81.553
2004	27	109.088	1	0.800	0	0.000	0	0.000	28	110.888
2005	12	77.517	0	0.000	1	30.660	1	9.400	14	119.577
2006	10	42.635	0	0.000	0	0.000	0	0.000	10	42.635
2007	26	177.778	0	0.000	0	0.000	4	64.606	30	246.384
2008	22	101.178	0	0.000	0	0.000	0	0.000	22	101.178
Total	127	619.099	1	0.800	1	30.660	10	131.600	139	794.159

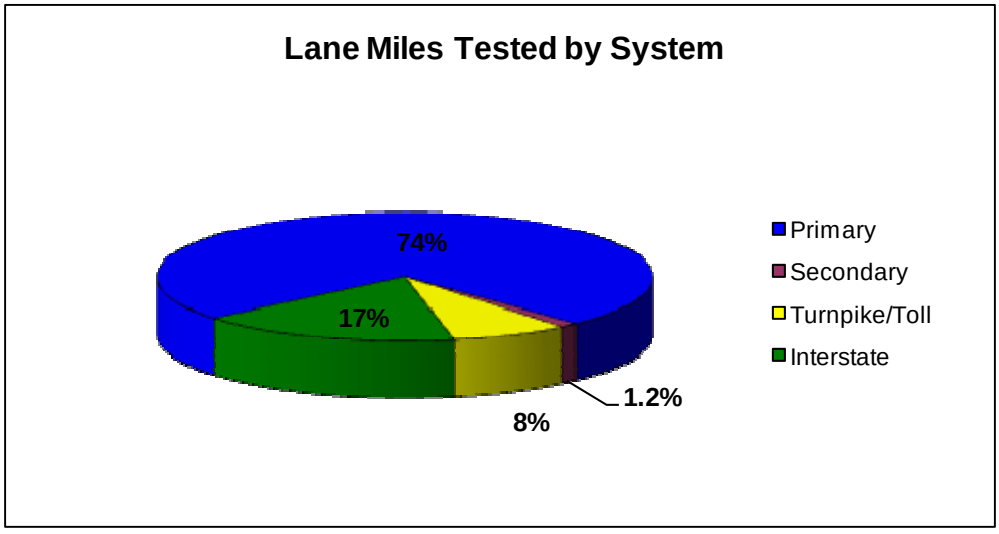




STATEWIDE TEN YEAR PRODUCTION SUMMARY

	Primary		Secondary		Turnpike/Toll		Interstate		All Systems	
	Projects	Lane Miles	Projects	Lane Miles	Projects	Lane Miles	Projects	Lane Miles	Projects	Lane Miles
1999	139	817.598	2	11.510	8	53.377	11	88.996	160	971.481
2000	91	609.985	2	7.910	5	20.160	14	157.960	112	796.015
2001	129	658.206	1	6.034	9	57.638	19	221.238	158	943.116
2002	256	1173.328	2	12.062	5	49.568	11	126.900	274	1,361.858
2003	165	826.387	3	8.659	7	136.114	27	358.516	202	1,329.676
2004	189	1065.841	3	7.368	6	139.858	12	214.918	210	1,427.985
2005	199	1183.239	7	27.935	6	333.188	19	244.980	231	1,789.342
2006	159	739.143	5	22.054	1	21.340	22	290.186	187	1,072.723
2007	154	782.638	3	8.520	2	17.484	18	181.482	177	990.124
2008	157	603.845	3	22.413	7	50.812	5	66.660	172	743.730
Grand Total	1638	8460.210	31	134.465	56	879.539	158	1951.836	1883	11,426.050





2007 PROJECT LISTING BY DISTRICT

District 1

County Section	Financial Project Number	County	State Road	Travel Direction	Beginning Milepost	Ending Milepost	Test Date	Mr (psi)	Comments
03040	195338-2	Collier	41	ET	5.934	6.376	4/8/08	21,000	
16180	197534-2	Polk	27	NT	24.602	27.925	4/22/08	30,000	
16180	197534-4	Polk	27	NTST	27.925	31.970	4/22/08	27,000	
16250	197627-2	Polk	37	NTST	19.010	23.259	4/23/08	18,000	
17070	197934-2	Sarasota	72	ETWT	0.000	4.490	3/18/08	21,000	
07010	408286-3	Hendry	80	ET	12.305	17.640	4/9/08	20,000	
12060	413695-1	Lee	78	WT	5.467	7.495	1/8/08	23,000	
N/A	415186-2	Hendry	CR 833	NT	0.000	9.944	4/29/08	16,000	Raw Data collected with 415186-2
16050	422391-1	Polk	600	NT	4.278	10.842	4/23/08	14,000	May be AC/PCC from MP 4.278 to 8.0 and from 9.0 to 10.842
16020	422392-1	Polk	600	ETWT	8.108	9.236	4/24/08	19,000	
16010	422393-1	Polk	600	WT	0.000	2.426	4/2/08	23,000	
09040	422394-1	Highlands	17 / 27	NTST	0.000	1.302	5/15/08	20,000	
17030	422395-1	Sarasota	789	ST	5.987	8.957	3/19/08	13,000	
16120	422397-1	Polk	655	NT	0.201	1.101	4/24/08	23,000	
13140	422398-1	Manatee	64	ET	4.947	10.735	4/16/08	15,000	
13050	422399-1	Manatee	70	ET	22.134	30.846	5/14/08	24,000	
03001	422400-1	Collier	84	ETWT	2.996	4.003	4/8/08	32,000	
12060	422402-1	Lee	78	ETWT	20.776	22.134	1/8/08	24,000	
13050	422403-1	Manatee	70	ET	30.846	37.021	5/14/08	28,000	
13050101	422404-1	Manatee	64	ET	0.189	1.510	4/10/08	20,000	
13080	422405-1	Manatee	789	NT	6.600	8.717	4/10/08	18,000	
13080	422406-1	Manatee	789	NT	4.950	6.600	4/10/08	17,000	
17030	422407-1	Sarasota	789	ST	3.870	5.987	3/19/08	12,000	
91020	422408-1	Okeechobee	15	NT	13.515	13.962	4/28/08	14,000	
13120001	422409-1	Manatee	70	ST	0.000	0.650	4/10/08	11,000	
13075	422498-1	Manatee	93	NTST	8.288	12.896	5/13/08	31,000	
03175	422499-1	Collier	I-75	NTST	49.248	53.341	4/8/08	32,000	

2007 PROJECT LISTING BY DISTRICT

District 1

County Section	Financial Project Number	County	State Road	Travel Direction	Beginning Milepost	Ending Milepost	Test Date	Mr (psi)	Comments
16030	197647-3	Polk	35	NT	8.272	9.900	4/2/08	30,000	
03080	425219-1	Collier	29	NT	19.980	28.578	11/18/08	23,000	
03010	195408-3	Collier	90	ST	24.687	28.414	11/18/08	19,000	
05010	423368-1	Glades	25	NTST	21.910	28.996	12/9/08	23,000	
06030	423637-1	Hardee	64	ET	10.600	12.000	12/10/08	12,000	
13150	423370-1	Manatee	64	ET	8.305	8.613	12/10/08	21,000	
17040	423369-1	Sarasota	780	ET	4.200	5.692	12/10/08	25,000	
16030	197647-3	Polk	35	NT	9.900	10.257	4/2/08	15,000	
16030	197647-3	Polk	35	ST	8.272	10.257	4/2/08	25,000	
13120001	422409-1	Manatee	70	ST	0.650	0.857	4/10/08	4,000	
16180	197534-2	Polk	27	ST	24.602	27.925	4/22/08	24,000	
91020	422408-1	Okeechobee	15	ST	13.515	13.962	4/28/08	22,000	
06030	423637-1	Hardee	64	ET	12.000	15.932	12/10/08	23,000	
17040	423369-1	Sarasota	780	WT	4.200	5.692	12/10/08	18,000	

2007 PROJECT LISTING BY DISTRICT

District 2

County Section	Financial Project Number	County	State Road	Travel Direction	Beginning Milepost	Ending Milepost	Test Date	Mr (psi)	Comments
32100	423432-1	Hamilton	93	NTST	8.874	19.175	5/7/08	25,000	
76020	209975-2	Putnam	19	NTST	21.935	22.964	3/13/08	14,000	
72070	209514-3	Duval	5	NT	3.700	5.496	5/8/08	21,000	
34010	210463-4	Levy	500	NTST	35.685	38.340	3/12/08	18,000	
35030	422917-1	Madison	20	NTST	0.000	5.794	2/11/08	21,000	
71070	208211-2	Clay	21	NTST	7.137	8.267	2/21/08	20,000	
29180	213076-2	Columbia	93	NTST	26.718	30.447	7/8/08	32,000	
72250	209129-2	Duval	105	NTST	0.560	1.405	7/17/08	19,000	
72250451	209129-2	Duval	105	NTST	0.000	0.328	9/8/08	19,000	
72070	209514-3	Duval	5	ST	3.700	5.496	5/8/08	12,000	

2007 PROJECT LISTING BY DISTRICT

District 3

County Section	Financial Project Number	County	State Road	Travel Direction	Beginning Milepost	Ending Milepost	Test Date	Mr (psi)	Comments
53070	423070-1	Jackson	2	ET	1.323	5.500	4/8/08	14,000	
53070001	423070-1	Jackson	2	ET	0.000	0.506	4/8/08	17,000	
61002	423056-1	Washington	77	NT	0.000	0.039	8/26/08	16,000	
61080	423056-1	Washington	77	NT	25.512	26.995	8/26/08	16,000	
59020	419315-1	Wakulla	369	ST	1.131	9.028	3/27/08	13,000	
57130	419314-1	Okaloosa	189	NTST	1.331	6.305	9/17/08	10,000	
57040	419313-1	Okaloosa	85	NTST	0.221	4.779	9/16/08	14,000	
57040024	419313-1	Okaloosa	85	NTST	0.000	0.125	9/16/08	14,000	
55090	419308-1	Leon	366	ETWT	0.835	2.694	2/28/08	21,000	Potential AC/PCC section. Informed Sam in the memo
53070	421642-1	Jackson	2	ET	12.946	17.450	4/8/08	25,000	
48030	423059-1	Escambia	290	ET	0.278	4.717	9/25/08	13,000	
48010	419302-1	Escambia	10	WT	0.643	7.480	9/24/08	14,000	
47010	419300-1	Calhoun	20	ET	0.000	12.560	3/25/08	12,000	
60050	413453-1	Walton	83	NT	0.055	13.611	8/27/08	13,000	
48004	419301-1	Escambia	727	NTST	8.320	10.043	9/24/08	12,000	
57030	416946-1	Okaloosa	30	ETWT	12.095	16.841	9/16/08	21,000	
53070	423070-1	Jackson	2	ET	5.500	7.300	4/8/08	23,000	
53070	423070-1	Jackson	2	ET	7.300	8.161	4/8/08	14,000	

2007 PROJECT LISTING BY DISTRICT

District 4

County Section	Financial Project Number	County	State Road	Travel Direction	Beginning Milepost	Ending Milepost	Test Date	Mr (psi)	Comments
N/A	415187-2	Broward	CR 833	NT	0.000	6.500	4/29/08	16,000	
94470	419603-1	St. Lucie	91	NT	31.200	35.100	7/31/08	26,000	
86190	421670-1	Broward	823	NTST	3.700	7.690	6/17/08	32,000	
93180	422990-1	Palm Beach	802	ET	7.200	8.010	6/18/08	21,000	
93200	422991-1	Palm Beach	804	ETWT	2.760	3.460	6/18/08	26,000	
86020	422998-1	Broward	5	NT	8.278	8.782	6/17/08	21,000	
86130	423006-1	Broward	849	NTST	2.271	3.228	6/17/08	20,000	
86050	423000-1	Broward	A1A	NTST	5.300	6.400	6/3/08	32,000	
86180	423007-1	Broward	A1A	ET	0.330	0.910	6/3/08	11,000	
86080	423004-1	Broward	84	ETWT	16.100	17.200	6/3/08	30,000	
93110	422986-1	Palm Beach	80	ETWT	2.500	4.000	7/23/08	19,000	
93170	422989-1	Palm Beach	717	NT	0.590	1.250	7/23/08	19,000	
93080	422984-1	Palm Beach	A1A	NT	3.380	4.000	7/22/08	20,000	
93040	422964-1	Palm Beach	5	NTST	2.389	9.500	6/4/08	24,000	
93010101	422961-1	Palm Beach	5	ST	0.050	2.377	6/18/08	20,000	
93150	422988-1	Palm Beach	809	NTST	7.470	11.080	7/22/08	20,000	
93310	422994-1	Palm Beach	710	ET	1.580	5.000	7/22/08	25,000	
94003	422957-1	St. Lucie	713	ST	7.500	9.517	7/17/08	20,000	
88010	422955-1	Indian River	5	NTST	0.000	1.830	6/19/08	13,000	
94010	422954-1	St. Lucie	5	NTST	20.890	21.451	7/17/08	17,000	
94060	423034-1	St. Lucie	A1A	ST	2.400	7.709	7/17/08	20,000	
93000121	N/A	Palm Beach	N/A	WT	1.210	2.264	7/23/08	2,000	Extremely weak embankment
88081	413049-1	Indian River	9	NTST	5.901	16.500	7/30/08	24,000	
89060	422953-1	Martin	76	ET	1.810	9.770	6/5/08	15,000	
88010	228583-4	Indian River	5	NTST	0.650	1.928	6/19/08	13,000	
86005	422866-1	Broward	838	ET	0.000	0.820	10/14/08	17,000	
93006	424645-1	Palm Beach	807	NTST	0.000	1.320	11/4/08	18,000	
93010	424647-1	Palm Beach	5	NT	8.390	10.780	11/4/08	20,000	
93030	424651-1	Palm Beach	806	ETWT	3.300	4.300	11/4/08	25,000	

2007 PROJECT LISTING BY DISTRICT

District 4

County Section	Financial Project Number	County	State Road	Travel Direction	Beginning Milepost	Ending Milepost	Test Date	Mr (psi)	Comments
93130	424655-1	Palm Beach	15	NT	3.030	4.000	10/28/08	19,000	
93130	424656-1	Palm Beach	15	NT	10.300	14.270	10/21/08	3,000	Extremely Weak Embankment
93160	424658-1	Palm Beach	25	NT	0.000	5.850	10/21/08	25,000	
93170	424659-1	Palm Beach	717	ET	0.000	0.530	10/21/08	3,000	Extremely Weak Embankment
93090	424654-1	Palm Beach	811	NTST	10.790	11.430	12/3/08	21,000	
93040	424652-1	Palm Beach	5	NTST	10.400	11.200	12/3/08	15,000	
93190	424660-1	Palm Beach	706	ETWT	16.040	16.860	12/3/08	16,000	
93280	424663-1	Palm Beach	704	ETWT	8.200	8.900	11/12/08	22,000	
93020	424650-1	Palm Beach	5	NT	6.100	6.700	10/22/08	18,000	
93001	424643-1	Palm Beach	786	ETWT	7.800	8.400	12/3/08	19,000	
93090	424653-1	Palm Beach	811	NTST	2.100	2.900	11/12/08	21,000	
93012	424648-1	Palm Beach	708	ETWT	0.850	1.960	11/12/08	20,000	
93012	424649-1	Palm Beach	708	ETWT	2.870	3.670	11/12/08	21,000	
93004	424644-1	Palm Beach	808	ETWT	1.180	2.000	11/4/08	27,000	
93010	424646-1	Palm Beach	5	NTST	1.400	2.600	11/12/08	18,000	
86012	424665-1	Broward	869	ETWT	0.000	1.820	10/15/08	25,000	
86014	424666-1	Broward	870	ETWT	0.000	0.800	10/15/08	21,000	
86170	424671-1	Broward	811	NTST	1.800	5.400	10/15/08	20,000	
86090	424668-1	Broward	816	ET	5.500	6.200	10/14/08	21,000	
86230	424674-1	Broward	822	ETWT	2.600	3.440	10/14/08	17,000	
93120	422987-1	Palm Beach	80	ET	20.390	21.000	10/22/08	10,000	
86170	230656-1	Broward	811	NTST	13.017	13.477	12/3/08	17,000	
93000157	231276-1	Palm Beach	811	NTST	0.000	0.234	12/3/08	17,000	
N/A	230622-1	Broward	Hammondville Rd.	ET	0.000	1.030	3/27/08	19,000	
N/A	230622-1	Broward	Hammondville Rd.	WT	0.000	1.030	3/27/08	25,000	
N/A	415187-2	Broward	CR 833	NT	6.500	7.500	4/29/08	8,000	
N/A	415187-2	Broward	CR 833	NT	7.500	9.355	4/29/08	16,000	
86180	423007-1	Broward	A1A	WT	0.330	0.910	6/3/08	17,000	

2007 PROJECT LISTING BY DISTRICT

District 4

County Section	Financial Project Number	County	State Road	Travel Direction	Beginning Milepost	Ending Milepost	Test Date	Mr (psi)	Comments
93180	422990-1	Palm Beach	802	WT	7.200	8.010	6/18/08	17,000	
86020	422998-1	Broward	5	NT	8.278	8.782	6/17/08	28,000	
93110	422986-1	Palm Beach	80	ET	4.000	4.460	7/23/08	7,000	Extremely Weak Embankment
93110	422986-1	Palm Beach	80	WT	4.000	4.460	7/23/08	3,000	Extremely Weak Embankment
93170	422989-1	Palm Beach	717	NT	1.250	1.700	7/23/08	6,000	
94470	419603-1	St. Lucie	91	ST	31.200	35.100	7/31/08	20,000	
86090	424668-1	Broward	816	WT	5.500	6.200	10/14/08	28,000	
86005	422866-1	Broward	838	WT	0.000	0.820	10/14/08	24,000	
93120	422987-1	Palm Beach	80	WT	20.390	21.000	10/22/08	19,000	
93160	424658-1	Palm Beach	25	ST	0.000	5.850	10/21/08	32,000	

2007 PROJECT LISTING BY DISTRICT

District 5

County Section	Financial Project Number	County	State Road	Travel Direction	Beginning Milepost	Ending Milepost	Test Date	Mr (psi)	Comments
36060	238648-1	Marion	45	NT	1.242	4.827	1/24/08	16,000	
11020	421974-1	Lake	33	ETWT	13.715	16.260	1/22/08	21,000	
11080	421976-1	Lake	19	NT	1.518	2.450	2/19/08	14,000	
18120	421989-1	Sumter	500	NTST	0.502	1.016	1/30/08	19,000	
75260	422011-1	Orange	424 / 434	NTST	4.854	6.576	1/28/08	22,000	Data Collected from MP 2.712
75290	422012-1	Orange	537	NT	0.000	1.027	5/6/08	27,000	
77080	422707-1	Seminole	436	ETWT	7.729	9.297	2/4/08	17,000	
77030	422708-1	Seminole	46	ETWT	8.448	8.929	2/4/08	16,000	
75472	423203-1	Orange	417	NTST	0.000	2.192	9/9/08	26,000	
92472	423202-1	Osceola	417	NT	0.000	2.906	9/9/08	22,000	
11070	423346-1	Lake	50	ET	0.000	4.293	2/7/08	21,000	
36180001	423348-1	Marion	326	ETWT	0.000	1.674	1/30/08	22,000	
70001	423350-1	Brevard	405	ETWT	0.000	4.406	2/5/08	20,000	
70140	423352-1	Brevard	3	NTST	1.057	3.386	2/5/08	16,000	
75006	423353-1	Orange	426	ETWT	0.000	1.043	5/6/08	24,000	
77060	423359-1	Seminole	426	ETWT	0.000	1.391	1/15/08	22,000	
79090	423360-1	Volusia	11	ST	1.690	14.316	3/10/08	19,000	
75190	423356-1	Orange	423	NTST	3.211	8.663	1/21/08	22,000	
79010	421621-1	Volusia	5	NTST	30.564	32.696	7/9/08	22,000	
11470	423198-1	Lake	91	ST	7.880	23.786	9/8/08	30,000	
77470	417545-1	Seminole	417	NTST	0.000	6.400	9/10/08	28,000	
75470	423198-1	Orange	91	NTST	24.558	24.913	9/9/08	30,000	
11470	423198-1	Lake	91	NTST	0.000	1.700	9/9/08	30,000	
79050	424902-1	Volusia	15	NT	16.180	17.190	11/18/08	17,000	
11080	421976-1	Lake	19	NT	2.450	3.300	2/19/08	24,000	
11080	421976-1	Lake	19	NT	3.300	3.700	2/19/08	14,000	
11080	421976-1	Lake	19	NT	3.700	4.822	2/19/08	20,000	
75290	422012-1	Orange	537	ST	0.000	1.027	5/6/08	22,000	
92472	423202-1	Osceola	417	ST	0.000	2.906	9/9/08	29,000	

2007 PROJECT LISTING BY DISTRICT

District 6

County Section	Financial Project Number	County	State Road	Travel Direction	Beginning Milepost	Ending Milepost	Test Date	Mr (psi)	Comments
90020	423135-1	Monroe	5	NT	6.317	6.794	6/17/08	13,000	
90020	423136-1	Monroe	5	NT	11.388	14.899	6/17/08	14,000	
87120	423134-1	Dade	90	ET	0.230	2.340	6/19/08	32,000	
87062	422723-1	Dade	959	ST	2.038	4.072	7/15/08	32,000	
87250	418239-1	Dade	944	ETWT	0.436	1.192	7/15/08	32,000	
87080001	410646-3	Dade	934	WT	0.000	0.250	8/5/08	7,000	
87026005	407736-1	Dade	860	ETWT	0.513	2.543	8/5/08	32,000	
87026005	407736-2	Dade	860	ETWT	2.543	3.664	8/5/08	32,000	
87053	414630-2	Dade	968	WT	6.089	8.650	6/19/08	23,000	
87053001	414630-2	Dade	968	ET	0.000	2.351	6/19/08	23,000	
90020	405612-2	Monroe	5	NT	25.221	26.548	12/2/08	18,000	
87037	249911-1	Dade	907	NTST	0.000	1.540	12/4/08	4,000	Extremely weak embankment
87060001	419860-1	Dade	A1A	ST	1.884	2.488	12/4/08	12,000	Potentially good project for Vibratory Analysis
87060	424579-1	Dade	A1A	NT	8.692	9.808	12/4/08	27,000	
87120	423134-1	Dade	90	WT	0.230	2.340	6/19/08	22,000	
87080001	410646-3	Dade	934	WT	0.250	0.761	8/5/08	32,000	
90030	405612-2	Monroe	5	NT	0.000	0.400	12/2/08	18,000	

2007 PROJECT LISTING BY DISTRICT

District 7

County Section	Financial Project Number	County	State Road	Travel Direction	Beginning Milepost	Ending Milepost	Test Date	Mr (psi)	Comments
15007	416836-1	Pinellas	595	NTST	0.000	3.041	6/24/08	21,000	
15230	411330-1	Pinellas	693	NT	2.223	5.342	7/1/08	26,000	
14120	413408-1	Pasco	52	WT	9.593	12.421	7/2/08	23,000	
14050	416624-1	Pasco	35	NTST	12.399	13.449	7/2/08	30,000	
14050	421526-1	Pasco	35	NT	20.887	22.300	7/2/08	24,000	
08020	423051-1	Hernando	55	NTST	0.000	3.707	7/3/08	25,000	
10190	423440-1	Hillsborough	400	ET	24.724	32.836	6/23/08	26,000	
10110	423053-1	Hillsborough	60	ETWT	16.479	20.273	6/11/08	32,000	
10110	423047-1	Hillsborough	60	ET	9.931	11.447	6/11/08	32,000	
10090	421525-1	Hillsborough	574	WT	11.200	12.540	9/2/08	17,000	
10030101	416849-1	Hillsborough	600	WT	0.000	1.782	5/28/08	15,000	possible HMA/PCC
10040	411335-1	Hillsborough	45	NTST	4.157	5.625	6/10/08	20,000	
10250101	406555-1	Hillsborough	585	ST	0.586	1.092	6/10/08	26,000	
10030	406554-1	Hillsborough	600	ET	20.607	24.593	5/28/08	15,000	Possible HMA/PCC
08070	406545-1	Hernando	50	ET	7.040	9.519	3/17/08	24,000	
10340	406553-1	Hillsborough	574	ETWT	1.265	3.317	6/10/08	26,000	
15070001	406548-1	Pinellas	580	ET	0.000	0.479	6/24/08	17,000	
15150	403731-1	Pinellas	55	NTST	5.890	7.292	7/1/08	19,000	
15020	403725-1	Pinellas	595	NT	7.267	10.261	6/24/08	18,000	
02010	257186-1	Citrus	45	NT	13.136	18.425	6/25/08	18,000	
08040	407951-3	Hernando	50	ETWT	0.000	3.760	3/17/08	23,000	
10110	423047-1	Hillsborough	60	WT	9.931	11.447	6/11/08	26,000	
15070001	406548-1	Pinellas	580	WT	0.000	0.479	6/24/08	23,000	
10190	423440-1	Hillsborough	400	WT	24.724	32.836	6/23/08	32,000	
02010	257191-1	Citrus	45	NT	18.425	29.986	6/25/08	18,000	
15230	411330-1	Pinellas	693	ST	2.223	5.342	7/1/08	20,000	

REFERENCES

1. Nazef A., and B. Choubane. *Survey of Current Practices of Using Falling Weight Deflectometers.* Research Report FL/DOT/SMO/01-452, Florida Department of Transportation, Gainesville, September 2001.
2. Bentsen, R. A., S. Nazarian, and J. a. Harrison. *Reliability Testing of seven Nondestructive Pavement Testing devices*. In Nondestructive Testing of Pavement and Backcalculation Moduli, ASTM STP 1026, A. J. Bush, III and G. Y. Baladi, Eds., American Society for Testing and Materials, Philadelphia, 1989.
3. *AASHTO Guide for the Design of Pavement Structures*. American Association of State Highway and Transportation Officials, Washington, D.C., March 1993.
4. Ullidtz, P. *Pavement Analysis*. Elsevier Science Publishers, New York, 1987.
5. Boussinesq, J. Application des Potentiels à l'Etude de l'Equilibre et du Mouvement des Solides Elastiques. Gauthiers-Villars, Paris 1885.
6. Jackson, N. M., Hammons, M. I., Walker, R. and H. Von Quintus. *Use of Nondestructive Techniques to Estimate the Allowable Vibratory Compaction Level during Construction*. Research Report FL/DOT/SMO/07-BDB-11, Florida Department of Transportation, Gainesville, March 2007.
7. Jackson, N. M., Choubane, B., Lee, H. S., Holzschuher, C., Hammons, M. and R. Walker. *Recommended Practice for Identifying Vibration Sensitive Work Zones Based on FWD Data*. In Transportation Research Record. No. 2081, TRB, National Research Council, Washington D.C., 2008, pp. 139-149.