King County

Pavement Evaluation

Use of Recycled Shingles In Hot Mix Asphalt on King County Unincorporated Roads

Performance and Progress Report

King County, Washington
January 2018

Prepared By:

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TO: Rick Brater, P.E., County Road Engineer,
Road Services Division, Department of Transportation

VIA: Alan D. Corwin, P.E., Materials Engineer, Materials Laboratory,
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FM: Kevin L. Kelsey, Senior Engineer, Materials Laboratory,
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Use of Recycled Asphalt Shingles in Hot Mix Asphalt
On King County Unincorporated Roads
Performance and Progress Report

As requested, we have completed a performance and progress review concerning the use of recycled asphalt shingles (RAS) in hot mix asphalt (HMA) on King County unincorporated roads. The following report includes an assessment of the past and current post-construction performance and a summary of progress using RAS.

Our evaluation has concluded there is no significant effect when incorporating RAS in HMA, per current acceptable specifications, and recommend the continued use of RAS on public roadways in King County.

Please contact Alan Corwin or me, should you have any questions, require clarification, or would like further information.

Cc: Jon Cassidy, P.E., Maintenance Engineering Manager,
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Use of Recycled Asphalt Shingles in Hot Mix Asphalt On King County Unincorporated Roads Performance and Progress Report

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1.0 INTRODUCTION

In 2009, The Road Services Division (RSD) of the King County Department of Transportation conducted a pavement demonstration project using recycled asphalt roofing shingles (RAS) in hot mix asphalt (HMA). The demonstration project provided the first documented use of RAS on a public roadway within Washington State.

Since its initial use, King County Road Services has provided an opportunity for paving contractors to use RAS in HMA, with certain restrictions. This report provides an assessment of post-construction performance using RAS in HMA and summarizes the progress of its use on unincorporated King County roadways.

1.1 BACKGROUND

King County is committed to recycling, and choosing products and services that have low environmental impacts (King County, 2015 Strategic Climate Action Plan). Recycling RAS can substantially reduce the amount of landfill waste.

According to the King County Solid Waste Division LinkUp Program, an estimated 29,000 tons of asphalt shingles are generated in King County, excluding Seattle, each year. The use of RAS provides a significant opportunity to divert a valuable material resource for use in pavements and save landfill space.

RAS contains a substantial amount of asphalt binder that can be substituted for a portion of the virgin asphalt binder. The environmental benefits associated with the use of shingles in paving are important incentives for incorporating RAS in HMA. Replacing virgin asphalt with recycled asphalt conserves nonrenewable resources and takes advantage of local supplies of materials that would otherwise go to waste.

2.0 POST-CONSRUCTION MONITORING OF RAS IN HMA

2.1 SE 416TH STREET PAVEMENT DEMONSTRATION (CONSTRUCTED 2009)

The Road Services Division (RSD) of the King County Department of Transportation, in partnership with the Solid Waste Division (SWD) of the King County Department of Natural Resources and Parks, and the Washington State Department of Transportation (WSDOT) Materials Laboratory conducted a pavement demonstration project in September 2009 using recycled asphalt roofing shingles in hot mix asphalt.

The demonstration project was initiated by the SWD LinkUp Program. The LinkUp Pro-

gram coordinates, facilitates, and collaborates with both public and private sectors to promote the use of recycled materials.

SE 416th Street, located in unincorporated King County near the City of Enumclaw, was overlaid with a 2-inch thick layer of Hot Mix Asphalt (HMA) incorporating both Recycled Asphalt Shingles (RAS) and Reclaimed Asphalt Pavement (RAP) in designated test sections. The demonstration project allowed the use of 3 percent RAS and 15 percent RAP by weight in the total HMA job mix for a combined total of 18 percent recycled materials.

Following completion of the overlay in 2009, the King County Materials Laboratory (KCML) performed pavement condition surveys through 2012 on a yearly basis by walking the site and documenting distressed areas. Pavement condition surveys, including pavement rutting and surface roughness, were also conducted by WSDOT using a distress data collection van.

The roadway was again surveyed in 2017 by KCML and WSDOT. The current and past conditions of the roadway are presented below.

2.1.1 Test Section

The roadway was divided into four separate test sections, each approximately ½ mile in length. Each test section required about 1000 tons of HMA to provide a 2-inch thick overlay. The test section layout for this project is shown in Table 1 below:

TABLE 1
SE 416TH Street Overlay
Test Section Layout

Lane Description	Test Section #1	Test Section #2	Test Section #3	Test Section #4
Stationing Limits	10+20 to 36+50	36+50 to 63+10	63+10 to 89+66	89+66 to 116+00
Materials Used	HMA Mix with 15% RAP Only	HMA Mix with 3% RAS and 15% RAP	HMA Mix with 3% RAS and 15% RAP	HMA Mix with 15% RAP Only

A Vicinity Map (Figure1) of the project site and a graphical depiction of the test section layout (Figure 2) are attached in Appendix A.

2.1.2 Pavement Condition Surveys

Pavement Condition Survey Methods

Post-construction pavement condition surveys were conducted by both KCML and WSDOT. For this project, KCML performed walking surveys using methodologies generally prescribed by The American Society for Testing and Materials (ASTM) test method D-6433-03 and the Northwest Pavement Management Association. WSDOT conducted drive-through surveys using laser and other sensing devices mounted to a distress data collection van.

Pavement Condition Survey Index (PCI)

Pavement distress observed during the respective surveys was categorized and quantified for the purpose of developing a Pavement Condition Index (PCI) for each test section.

PCI is a numerical indicator that rates the present condition of the pavement surface based upon the type, quantity, and distress levels observed. A newly constructed pavement would have a PCI of 100 and a roadway that has failed would have a rating near 0. ASTM suggests using terminology shown in Table 2 to describe the condition of pavements based upon various PCI rating ranges.

TABLE 2	
SE 416TH Street Overlay	
PCI Rating Ranges	
PCI Rating	**Condition Description**
85 to 100	Excellent
70 to 85	Very Good
55 to 70	Good
40 to 55	Fair
25 to 40	Poor
10 to 25	Very Poor
0 to 10	Failed

WSDOT designates a Pavement Condition Index (PCI) as a Pavement Structural Condition (PSC). The PSC is a scoring of the pavement structure based on a compilation of visible surface distresses. This score ranges from 100 being a new surface absent of any distress to 0 representing total pavement failure. The ratings are similar to those presented in Table 2 (PCI Rating Ranges).

Post-construction pavement condition surveys Conducted by WSDOT and KCML are summarized below in Table 3 and Table 4, respectively. Test Sections 1 and 4 contain 15 percent RAP only. Test Sections 2 and 3 contain 3 percent RAS and 15 percent RAS.

Table 3				
SE 416th Street Overlay				
WSDOT Post Construction Pavement Condition Surveys				
Test Section	**Materials**	**2010**	**2012**	**2017**
Test Section 1	RAP Only	100	99	99
Test Section 2	RAP and RAS	100	99	99
Test Section 3	RAP and RAS	100	100	99
Test Section 4	RAP Only	100	99	99
Overall Rating	N/A	100	99	99

Table 4				
SE 416th Street Overlay				
KCML Post Construction Pavement Condition Surveys				
Test Section	**Materials**	**2010**	**2012**	**2017**
Test Section 1	RAP Only	100	100	99
Test Section 2	RAP and RAS	100	100	97
Test Section 3	RAP and RAS	100	99	96
Test Section 4	RAP Only	100	99	97
Overall Rating	N/A	100	99	97

Note: Test results are rounded to whole numbers. Ratings are based on the combined average of both lanes in each test section.

The roadway surface in all test sections continues to appear in excellent condition following eight (8) years of post-construction service. There was no observed or measured significant difference between the test sections with RAS and the control sections without RAS.

Pavement Rutting Condition (PRC)

The WSDOT distress data collection van documented the pavement rutting condition (PRC) using a Laser Rut Measurement System (LRMS) mounted on the distress data collection van. Two of these collection devices are mounted on the back of the collection van, one for each half of the lane width. The devices collect laser images every 5 feet through the length of the site.

PRC is a score representing the extent of rutting present in the rated lane. The PRC rating scale ranges from 100 (no rutting) to 0 (deep rutting dependent on the length). Typically, a roadway would be considered in need of rehabilitation when the PRC rating is 50 or below. Post-construction PRC test results from the WSDOT pavement condition surveys are summarized in Table 5.

Table 5
SE 416th Street Overlay
WSDOT Pavement Rutting Condition Surveys (PRC) – Post Construction

	August 2010		November 2011		January 2013		October 2017	
Test Section	PRC	Average Depth (inches)	PRC	Average Depth (inches)	PRC	Average Depth (inches)	PRC	Average Depth (inches)
1	95	0.06	96	0.07	95	0.07	93	0.10
2	96	0.06	96	0.06	96	0.07	91	0.12
3	95	0.07	96	0.07	96	0.07	90	0.12
4	94	0.08	94	0.09	94	0.08	90	0.12
Average	95	0.07	96	0.07	95	0.07	91	0.12

Note: Ratings are based on the combined average of both lanes in each test section.

All roadway test sections continue to exhibit only minimal rutting following eight (8) years of service.

International Roughness Index (IRI)

WSDOT also recorded surface roughness based on the International Roughness Index (IRI). The collection van is outfitted with two accelerometers, one for each wheel path. As the van travels over the test site the accelerometers measure the axle movement of the van, recording surface irregularities.

For this rating, the scoring ranges from low to high and is measured in inches per mile. The higher the score, the rougher the roadway section, with zero considered equivalent to a smooth glass surface. WSDOT uses the following rankings, shown in Table 6, when rating the IRI:

TABLE 6	
SE 416th Street Overlay	
International Roughness Index Scale	
IRI (inches/mile)	Pavement Rating
Below 95	Very Good
95-170	Good
170-220	Fair
220-320	Poor
Above 320	Very Poor

Post-construction IRI test results from the WSDOT pavement condition surveys are summarized in Table 7:

TABLE 7				
SE 416th Street Overlay				
WSDOT International Roughness Index Surveys (IRI) Post Construction				
Test Section	August 2010	November 2011	January 2013	October 2017
Test Section 1	60	67	62	63
Test Section 2	64	60	62	60
Test Section 3	91	92	92	96
Test Section 4	82	88	80	87
Overall Rating	74	77	74	76

Note: Test results are rounded to whole numbers. Ratings are based on the combined average of both lanes in each test section.

The roughness (IRI) of the roadway continues to be measured below a rating of 95 in all test sections, except for Test Section 3, indicating a relatively smooth surface since placement of the overlay. Test Section 3 was rated at 96 or in good condition. A small bridge crossing is located within Test Section 3. Differential settlement at both bridge approaches most likely increased the overall roughness rating of the roadway when compared with other test sections.

2.1.3 Summary of 2017 Survey Findings

Both KCML and WSDOT post construction surveys revealed a PCI or PSC rating of nearly 100 for each test section, following eight (8) years of service life. The entire roadway in all test sections is considered to be in excellent condition.

Pavement rutting condition (PRC) survey test results revealed relatively no change in the degree of rutting in any of the test sections. PRC values were similar in all test sections. Minimal but expected rutting within the roadway has occurred in all test sections.

Except for Test Section 3, the roughness (IRI) of the roadway continues to be measured below 95 in all test sections indicating a relatively smooth surface since placement of the overlay. Test Section 3 scored a 96 or good rating. The slightly higher score may be attributed to traveling over the existing Newaukum Creek Bridge located within Test Section 3. Overall, the severity of roughness has marginally increased since construction.

3.0 SUMMARY OF DEVELOPMENTS SINCE 2009

3.1 RECYCLED ASPHALT SHINGLES (RAS) SPECIFICATION GUIDELINES

In 2010, the LinkUp Program developed specification guidelines for the use of RAS in HMA based on specifications used and experience gained from the 2009 Demonstration project. The document provides guidelines for the safe handling and processing of RAS, as well as recommendations for quality control testing. The guidelines were last updated in January, 2012 and can be found on the LinkUp Program website (King County 2012 RAS Specifications Guidelines).

3.2 BOW LAKE RECYCLING AND TRANSFER STATION (2011–2012)

RAS in HMA was utilized during Phase 1 reconstruction of the King County SWD's Bow Lake Recycling and Transfer Station. Paving operations took place in 2011 and 2012. Phase 1 included paving the access road to the transfer building and fueling facility, and surrounding parking. The transfer building has been open since July 2012 and has endured heavy traffic loading. RAS is now accepted for use on all King County SWD projects.

3.3 CHANGES TO THE SPECIFICATION (2012–2014)

3.3.1 WSDOT Specifications

Shortly after the completion of pavement demonstration on SE 416th Street, WSDOT began developing specifications for the use of RAS in HMA. Of concern to WSDOT, was the fact that recovered asphalt binder consisting of RAS, RAP, and conventional HMA on SE 416th Street was tested and graded at PG 76-16.

The typical asphalt binder grade recommended and specified for use on King County Roadways within the lowlands of Puget Sound is PG 64-22. The first number in the notation represents the predicted average 7-day maximum pavement temperature in Celsius expected in the region. Therefore, the maximum pavement temperature expected in the Puget Sound region is 64 degrees Celsius or 147 degrees Fahrenheit. The second number represents a minimum expected pavement temperature of -22°C or -7.6°F.

A grading of PG 76-16 indicates that at higher pavement temperatures, the pavement is less likely to rut. However, due to the increased stiffness, fatigue cracking may occur at an accelerated rate. During colder temperatures, this binder may become more brittle and susceptible to thermal cracking when compared to HMA mixes containing an asphalt binder graded at PG 64-22.

WSDOT addressed the concerns regarding changes in asphalt binder performance grade by requiring the HMA supplier to meet the PG grade specified in the contract documents for each individual project. This would most likely require the asphalt supplier to incorporate an asphalt rejuvenator into the job mix or use a softer virgin binder PG grade to adjust the final HMA binder to the required performance grade, typically PG 64-22.

In 2012, WSDOT published General Special Provisions for the use of RAS in HMA. The

specifications consisted of a series of modified excerpts to Section 5-04 of the WSDOT 2012 Standard Specifications for Road, Bridge, and Municipal Construction.

The Special Provisions allow up to 5 percent RAS by total weight of the HMA, provided the final performance grade of asphalt binder meets the performance grade required in each specific Contract. This may require adding an asphalt binder rejuvenator to adjust the final asphalt binder performance grade and/or adjusting the PG grade of the virgin binder to a softer grade to accommodate the stiffer binder in RAS.

The Special Provision for the use of RAS was included as a Standard Specification in the 2014 WSDOT Standard Specifications for Road, Bridge, and Municipal Construction. The specification for the use of RAS was again updated in the 2016 Standard Specifications.

3.3.2 King County Materials Laboratory Recommendations for Special Provisions

In 2012, following 3 years of post-construction monitoring, pavement condition surveys verified the entire surface of the roadway on SE 416th Street remained in excellent condition and performing as well as, if not better than, other typically overlaid roadways in King County following three years of service life.

Observations and test results continued to indicate there was no significant effect, favorable or detrimental, on pavement performance when incorporating a maximum of 3 percent RAS by total weight to HMA.

On the basis of information obtained during post-construction monitoring, KCML recommended the use of RAS in HMA on overlays, new road construction, and maintenance projects, under a set of King County Special Provisions with the maximum amount of RAS being no greater than 3 percent and RAP no greater than 15 percent by total weight of the HMA job mix.

Concurrently, KCML recommended allowing the unlimited use of RAS in HMA on County roadways, provided the pavement contractor meets all specifications as required in the newly developed 2012 WSDOT General Special Provisions and subsequent 2014 Standard Specifications.

4.0 CURRENT USE OF RAS IN HMA ON KING COUNTY ROADWAYS

4.1 KING COUNTY OVERLAY PROGRAM: (2014-2015)

In 2014, Miles Sand and Gravel was the low bidder on the King County Overlay program and submitted a mix design using RAS in HMA. The design was formulated using a softer virgin asphalt binder (PG 58-28), and incorporating 3 percent of RAS and 15 percent RAP into the HMA design mix. Following the addition of the recycled materials, the asphalt binder graded to PG 64-22. Paving was completed in 2015. Nearly 22,000 Tons of RAS in HMA were used to pave about 17 lane miles in King County.

Subsequent post-construction monitoring in 2017 consisting of a visual windshield survey indicated that all roads paved with RAS in 2015 scored a PCI rating of 100.

4.2 KING COUNTY OVERLAY PROGRAM: 2017

Miles Sand and Gravel also won the pavement overlay contract in 2017. 56,770 tons of RAS in HMA were placed on over 30 lane miles of roadway in 2017. This equates to about 1700 Tons of RAS used in 2017. Additional roadways will be paved with the inclusion of RAS in 2018 to complete the 2017 contract.

5.0 CONCLUSION

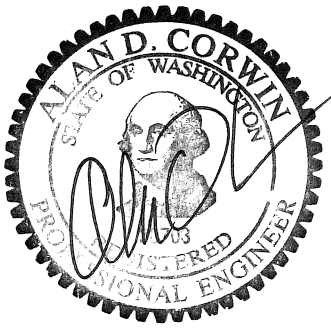
The SE 416th Street demonstration project provided the first documented use of RAS on a public roadway within Washington State. Post-construction surveys on the roadway following eight (8) years of service life indicate the entire roadway in all test sections is still considered to be in excellent condition. In addition, post-construction monitoring in 2017 revealed that all roads paved in 2014 with RAS in HMA are also in excellent condition.

The use of RAS in HMA has resulted in removing a substantial amount of shingles from King County landfills as well as reducing the amount of virgin asphalt needed to pave County roadways.

King County Road Services Division should remain committed to encourage paving contractors to use RAS in HMA and continue to communicate and collaborate with King County Agencies, other local government agencies, and WSDOT on the progress of utilizing RAS in HMA.

Respectfully Submitted,

King County Materials Laboratory



1/17/18

Alan D. Corwin, P.E.
Materials Engineer

Kevin L. Kelsey
Senior Engineer

6.0 REFERENCES

ASTM Standards, Volume 04.03, *ASTM D 6433-07 Standard Practice for Roads and Parking Lots Pavement Condition Index Surveys,* 2009.

King County Department of Transportation, Road Services Division, *SE 416th Street Overlay: Shingles in Paving Demonstration, Special Provisions,* June 2009.

King County Department of Natural Resources and Parks, Solid Waste Division, LinkUp website – http://your.kingcounty.gov/solidwaste/linkup/shingles/resources.asp

King County Executive Services, *Strategic Climate Action Plan,* November 2015.

King County Materials Laboratory, *Technical Support Document for SE 416th Street Overlay: Shingles in Paving Demonstration*, January 2010.

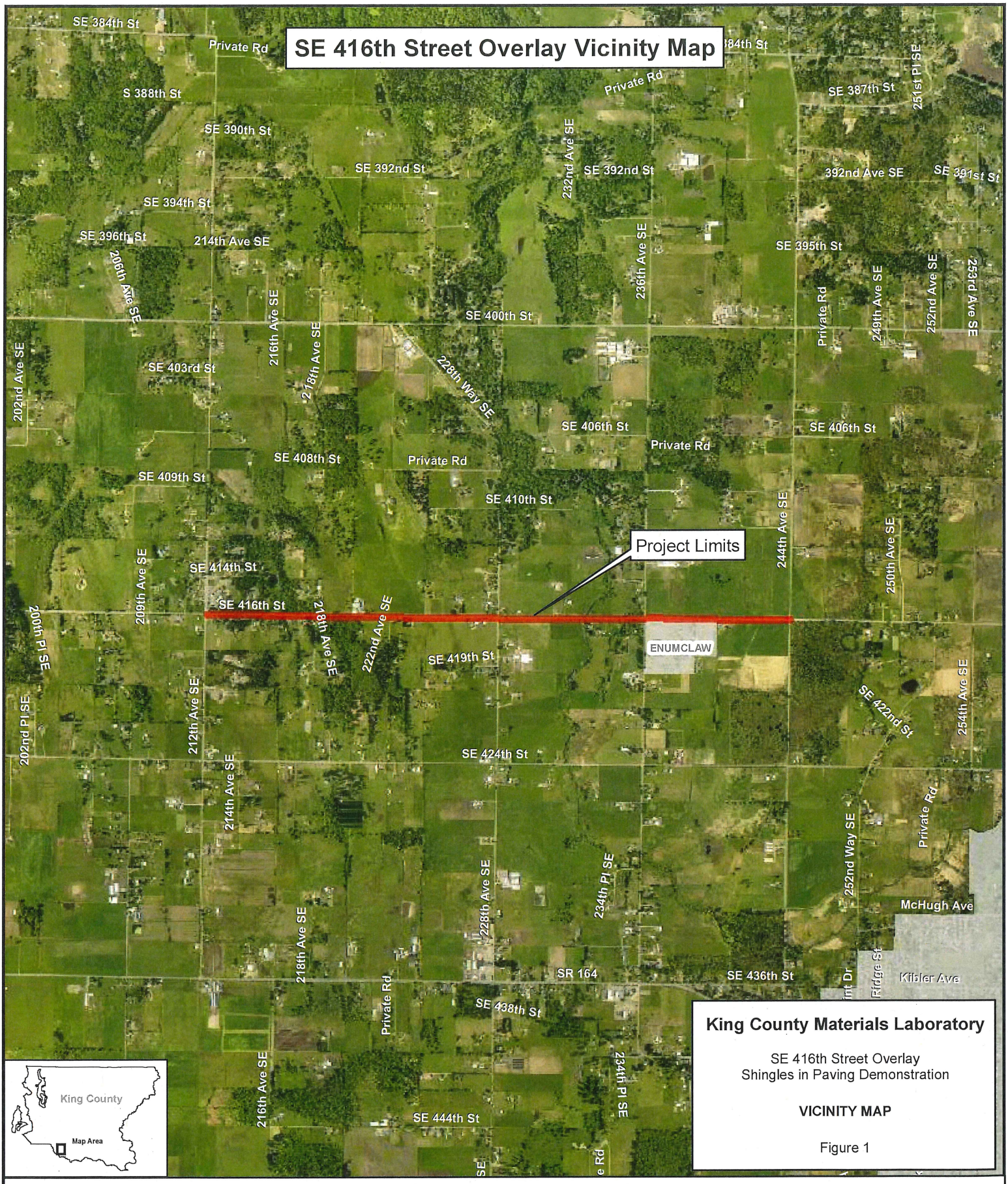
King County Materials Laboratory, *SE 416th Street Overlay: Shingles in Demonstration, Post-Construction Pavement Condition*, September 2010

King County Materials Laboratory, *SE 416th Street Overlay: Shingles in Demonstration, Post-Construction Pavement Condition – Interim Report*, January 2012

King County Materials Laboratory, *SE 416th Street Overlay: Shingles in Demonstration, Post-Construction Pavement Condition – Final Report*, October 2013

Northwest Pavement Management Association, *Pavement Surface Condition Field Rating Manual for Asphalt Pavement, Second Edition,* undated.

Washington State Department of Transportation, *Standard Specifications for Road, Bridge, and Municipal Construction,* 2016


SE 416th Street Overlay Vicinity Map
SE 384th St
Private Rd
S 388th St
SE 390th St
SE 392nd St
232nd Ave SE
SE 387th St
251st Pl SE
392nd Ave SE
SE 391st St
SE 394th St
SE 396th St
214th Ave SE
206th Ave SE
236th Ave SE
SE 395th St
249th Ave SE
252nd Ave SE
263rd Ave SE
216th Ave SE
218th Ave SE
SE 400th St
202nd Ave SE
SE 403rd St
228th Way SE
SE 406th St
SE 408th St
SE 409th St
SE 410th St
244th Ave SE
250th Ave SE
Project Limits
209th Ave SE
SE 414th St
SE 416th St
200th Pl SE
222nd Ave SE
ENUMCLAW
SE 419th St
202nd Pl SE
212th Ave SE
SE 422nd St
254th Ave SE
SE 424th St
214th Ave SE
234th Pl SE
252nd Way SE
McHugh Ave
228th Ave SE
SR 164
SE 436th St
Kibler Ave
SE 438th St
SE 444th St
King County
Map Area
King County Materials Laboratory
SE 416th Street Overlay
Shingles in Paving Demonstration
VICINITY MAP
Figure 1
Project Limits
City
2009 King County natural color orthophoto - 0.5 GSD
N
January 7, 2010
0 0.25 0.5 Miles
File Name:
KG TUdevelopment\ArcMap\ArcMapProjects\SE_416th_St_vicinity_map.mxd
Data Sources:
Standard King County datasets used include: trans_network,
2009 King County natural color orthophoto - 0.5 and 1.0 ft GSD
Roads Datasets Include:SE314thSt
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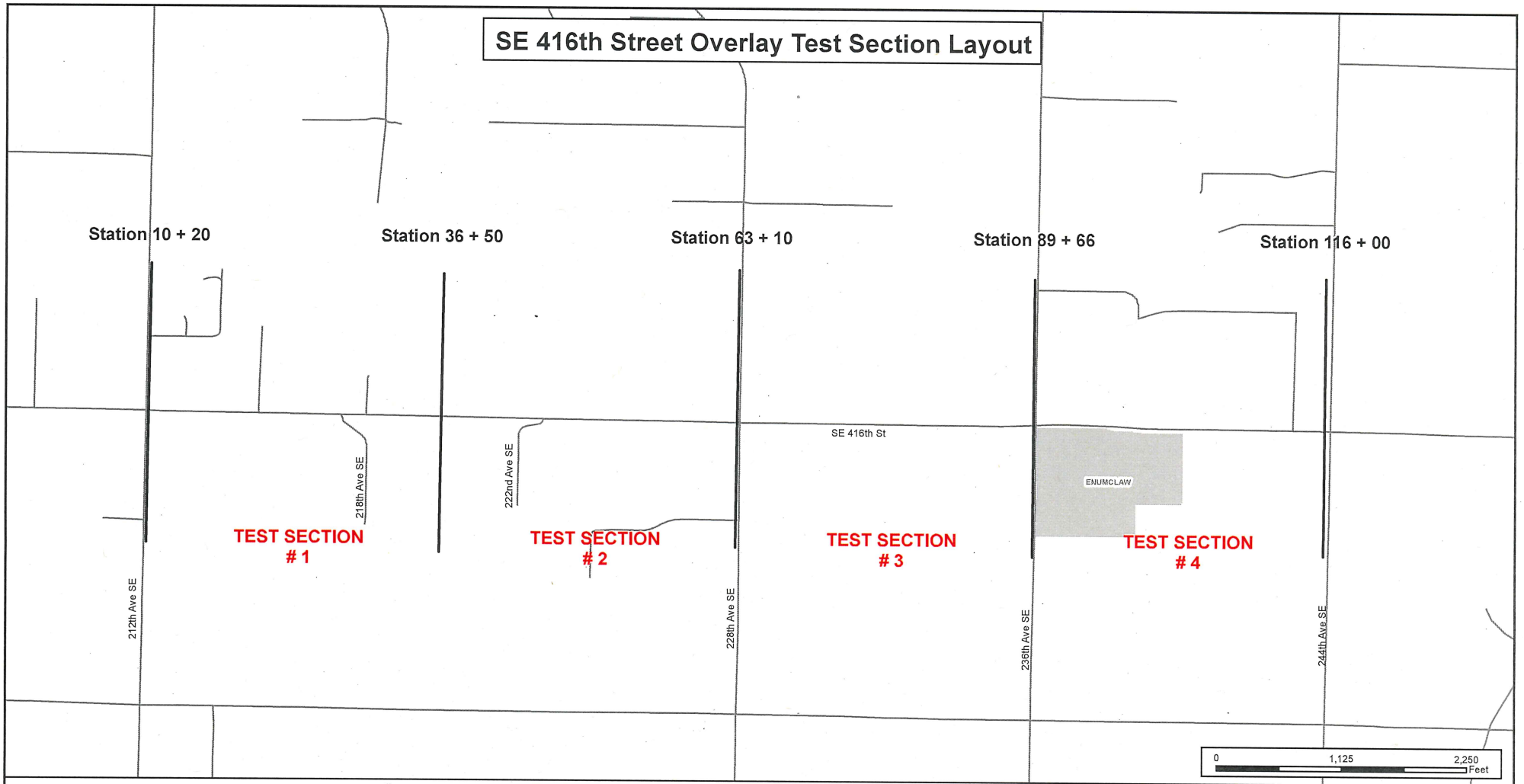

King County Materials Laboratory

SE 416th Street Overlay
Shingles in Paving Demonstration

TEST SECTION LAYOUT

Figure 2

Station Line
Street Network

N

January 7, 2010

File Name:
KG TUdevelopment\ArcMap\ArcMapProjects\SE_416th_St_test_section_map.mxd
Data Sources:
Standard King County datasets used include: trans_network
Roads Datasets Include: SE416thSt_stationing

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