APPENDICES

The following appendices are included in this report.

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APPENDIX A. ACRONYMS, ABBREVIATIONS, AND Key Terms

This appendix presents definitions for key terms used in this report.

Appendix A. Acronyms, Abbreviations, and Key Terms

Acronyms and Abbreviations

Acronym	Term
AC	Asphalt content
ACP	Asphalt concrete pavement
AASHTO	American Association of State Highway and Transportation Officials
AHERA	Asbestos Hazard Emergency Response Act
AC	Asphalt content
ATB	Asphalt treated base
BBR	Bending beam rheometer
C&D	Construction and demolition
CSBC	Crushed surface base course
D/A	Dust to asphalt binder ratio
DSR	Dynamic shear rheometer
Ecology	Washington State Department of Ecology
FWD	Falling weight deflectometer
IRI	International roughness index
KCDOT	King County Department of Transportation
KCRSD	King County Road Services Division
KCSWD	King County Solid Waste Division
L&I	Washington State Labor and Industries
NAPA	National Asphalt Pavement Association
Ndes (or Ndesign)	Number of design gyrations
Nini (or Ninitial)	Number of initial gyrations at design
PAV	Pressurized aging vessel
Pb	Percent binder
Pbe	Percent binder effective
PCC	Portland cement concrete
PCI	Pavement condition indices
PLM	Polarized light microscopy
PRC	Pavement rutting condition
PSC	Pavement structural condition
RTFO	Rolling thin-film oven
SPU	Seattle Public Utilities
SDOT	Seattle Department of Transportation
TEM	Transmission electron microscopy
Va	Air voids
VMA	Voids in mineral aggregate

VFA	Voids filled with asphalt
WAPA	Washington Asphalt Paving Association
WSDOT	Washington State Department of Transportation
Woodworth	Woodworth & Company, Inc.

Definitions of Key Terms

Term	Definition
Asbestos-containing materials (ACM)	Any material containing more than 1% asbestos as defined by WAC 296-62-07703.
Asphalt shingle recycling facility (or "Recycling Facility")	The physical plant (or plants) where tear-off asphalt shingles are received, processed into a finished RAS product, tested and stockpiled. This may include separate transfer locations.
Core Project Team	KCSWD (project manager), KCRSD (project sponsor), WSDOT (HMA mix design lead), and the supporting consultant team. Woodworth (paving contractor) joined the Core Project Team later as the contracted RAS processor, HMA producer, and paving contractor.
Bulk specific gravity (Gmb)	Bulk specific gravity of compacted specimen
Maximum specific gravity (Gmm)	Maximum specific gravity of the paving mixture
Gravity stone effective (Gse)	Specific gravity of aggregates, excluding voids permeable to asphalt
Hot mix asphalt (HMA)	Mixture of aggregate and liquid asphalt heated in a mixing plant and transported and installed on a road surface before cooling
HMA producers	Companies that manufacture HMA from aggregates and asphaltic materials
Invitation to Bid (ITB)	For the overlay paving work on SE 416th Street near Enumclaw, WA. The ITB as released by KCRSD in August 2009 for purposes of the SIPD Project.
King County LinkUp program (LinkUp)	The recyclable materials market development program of the King County Solid Waste Division
Mixed roofing loads	Loads of roofing waste that include a mixture of tear-off shingles and other roofing debris, such as roofing felt, tar paper, and mastic
Overlay paving	An overlay is any operation that consists of laying either Portland Cement Concrete (PCC) or HMA over an existing pavement structure. This is different than a total replacement of the structure, and is typically done when there is only minor to modest damage to the existing pavement structure.

	When constructing an overlay, the old surface is typically milled or ground off. Any minor structural deficiencies are then repaired. Finally, a new surface is applied.
Paving Contractors	The road construction companies that install the PCC or HMA pavement
Processors	Shingle recyclers that covert whole shingles into RAS through a process of grinding or crushing
Reclaimed (or recycled) asphalt pavement (RAP)	Ground, screened product derived from old bituminous paving surfaces. Alternative sources of RAP can include either bituminous chunks of pavement (i.e., not milled) and/or millings from on-site grinding / reclamation equipment.
Recycled asphalt shingles (RAS)	The finished product derived from crushing, grinding, screening, and otherwise processing asphalt shingles. RAS is most often processed into a form ready for use in HMA plants.
Recyclers	Company with a facility equipped to convert raw recyclable materials (e.g., whole shingles) into products (e.g., RAS) that can be used by end markets (e.g., HMA producers)
Request for Information (RFI)	One of the initial steps in the paving demonstration procurement process. The RFI was released by KCSWD in August 2008 for purposes of general background research and information gathering.
Request for quotations (RFQ)	A second step in the paving demonstration procurement process. RFQ as released by KCRSD in August 2008 for purposes of gathering quotations for the purchase of RAS.
Tear-off asphalt shingles	Previously used asphalt shingles derived primarily from re-roofing projects whereby the old shingle layers are removed to prepare the roof surface for new shingles and / or other roofing materials.
Thin asphalt overlay	These overlays are 1.5 inches or less in thickness, and comprised of aggregate having a small nominal maximum aggregate size, generally 12.5 mm or less.[1]
Whole shingles	Shingles that may have been sorted, but have not yet been ground into RAS for use in a new material or product, such as HMA

[1] *Thin Asphalt Overlays for Pavement Preservation* published by NAPA (July 2009). For a free downloadable copy, link to: http://www.hotmix.org/images/stories/is-135.pdf.

Thin asphalt overlay	These overlays are 1.5 inches or less in thickness, and comprised of aggregate having a small nominal maximum aggregate size, generally 12.5 mm or less.[1]
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[1] *Thin Asphalt Overlays for Pavement Preservation* published by NAPA (July 2009). For a free downloadable copy, link to: http://www.hotmix.org/images/stories/is-135.pdf.

APPENDIX B. RESEARCH MEMOS

This appendix includes four research memos written for the LinkUp Shingles Project.

- Summary of status of composition shingle recycling. April 7, 2006.
- Summary of research on existing markets and processing capacity for tear-off asphalt shingles. December 15, 2006.
- Recycled asphalt shingles in hot mix asphalt research: summary of relevant projects. October 4, 2007.
- Preliminary response on long-term pavement performance and safety issues. December 30, 2008.

MEMO

Date: April 7, 2006

To: Kris Beatty, LinkUp Program Manager, King County Solid Waste Division

From: Amity Lumper, Charlie Scott, Cascadia Consulting Group, Inc.
Julie Colehour, Colehour + Cohen
David Dougherty, Dougherty Group

Re: Summary of composition shingle recycling

This is a summary of the status of composite shingle recycling, both in the Northwest and other areas in the county with successful programs. The information presented in this report is based on interviews with the following organizations.

Organization	Contact person(s)
Woodworth & Co.	John Grisham
American Roofing Recyclers	Marv Reykdal
Recovery 1	Terry Gillis
Minnesota Office of the Environment	Don Kyser

Current status

Based on a 2002 King County C&D study, about 17,000 tons of shingles are generated by C&D activities each year, less than 1,000 of which are being recycled. An additional 6,000 tons of shingles and siding are disposed by residential and commercial generators in the County, according to the 2002 King County Waste Characterization Study.

Though residential roofing and re-roofing activities generate large quantities of asphalt shingle waste, few opportunities exist for recycling this material. Until 2001, the Tacoma Steam Plant accepted asphalt shingles, for a tip fee, to be burned as fuel. There are no plans to reopen the Steam Plant at this point.

After the Tacoma Steam Plant closed down, recyclers in the region have had a difficult time finding viable markets for composite shingles. Most of the shingles currently colleted for recycling go to hog fuel markets, with a limited amount used to make asphalt and aggregate products.

Barriers to recycling

The following were identified as major barriers to composite shingle recycling.

- Lack of WSDOT specifications for use in roadway materials such as hot mix asphalt and aggregate road base

- Presence of asbestos, especially in 3-tab shingles torn off from older commercial buildings
- Difficultly of removing nails, staples and other non-ferrous metal items during processing

Supply

Each year, nearly 30,000 tons of composite shingles are disposed by Seattle and King County residents and businesses. The breakdown is as follows:

- 16,000 tons from C&D industry in King County, excluding Seattle
- 6,000 tons from commercial and residential sources in King County, excluding Seattle
- 1,500 tons from Seattle residents and businesses
- 10,000 tons from C&D industry in Seattle

Asphalt shingles are used as a roofing material, and they are the most popular type of residential shingle used today. In the U.S., 80% of homes are roofed with asphalt shingles, resulting in over 12.5 billion square feet of asphalt shingle products manufactured annually.

Processing

Processing composite shingles typically involves grinding and screening the material for specific market applications. Screening sizes vary depending on the application. When used as an interim landfill cover, grinding is not required.

Currently, American Roofing Recyclers is the only composite shingle processor in the region, processing about 7,000 tons annually. Recovery 1 only accepts shingles as part of mixed loads from demolition activities, and Woodworth & Co. recently discontinued their shingle recycling operation because of water quality issues (used to process approximately 6,000-8,000 tons per year). These processors reported customer prices between $56 and $75 per ton.

End markets

Local processors are most interested and see the largest potential in the use of recycled shingles in roadway applications, such as hot mix asphalt and aggregate road base. Minnesota estimated that approximately 75% of all asphalt is used in government projects and 25% is used in private spec projects.

Other potential end markets for recovered shingles are:

- Fuel source
- Interim landfill cover
- Pipe bedding

Opportunities

The primary opportunity identified is to work with WSDOT to advocate for the use of asphalt shingles in road base and hot mix asphalt. Other state departments of transportation, such as Maine, Minnesota and Ohio specify are successfully using recycled shingles in roadway applications. WSDOT specifications are widely used by local governments and in private roadway projects.

KCLinkUp Market Development: Shingles
Summary of Steps 1 and 2 Research

Step 1: Research existing markets for tear-off asphalt shingles

WSDOT

Although WSDOT is not currently using tear-off shingles in paving applications, they are using up to 20% recycled asphalt paving (RAP). We learned that they are considering using tear-off shingles in pavement, although our contact believed it will be a slow process to implement this new practice. The biggest barriers are, reportedly, quality control, access to a consistent supply, and the large amount of mineral filler.[#] Another contact at WSDOT was concerned about the stiffness of the asphalt in shingles and thought it might lead to cracking.[ϰ]

[#]Baker, Thomas. State Materials Engineer for WSDOT and Chair of the AASHTO Subcommittee on Materials. Personal communication, 12/1/06.

[ϰ] Walter, Jim. WSDOT Maintenance and Operations Programs. Personal communication, 12/1/06.

Manufacturers and contractors

We contacted the 19 companies listed as members on the website of the Washington Paving Association (Table 1). Of the 19 companies, four did not return calls and 11 responded that they were not interested or were not familiar with the use of tear-off shingles in asphalt paving. Four companies were interested in using this material as a feedstock for paving mixes. One of these companies has been grinding tear-off shingles for use as roadbed material.

Table 1. Washington Asphalt Paving Association Members

Company	Based in	Interested in processing shingles
Ace Paving Company, Inc.	Bremerton	No
Central Washington Asphalt, Inc.	Moses Lake	Didn't return calls
Degerstrom, Inc.	Omak	No
Icon Materials	Kent	No
Inland Asphalt Company, Inc.	Spokane	No
Krieg Construction, Inc.	Oak Harbor	Maybe
Lakeside Industries	Issaquah	Interested
Marysville Paving & Construction, Inc.	Shohomish	No
Naselle Rock & Asphalt Co.	Naselle	No
Poe Asphalt Paving, Inc.	Lewiston, ID	No
Rinker Materials	Everett	Interested – Having trouble with Ecology permit
Superior Asphalt & Concrete Co.	Yakima	Didn't return calls
Tucci & Sons, Inc.	Tacoma	Maybe – Use recycled asphalt paving
Valley Asphalt	Colville	No
Watson Asphalt Paving Co., Inc.	Redmond	No
Western Asphalt, Inc.	Maple Valley	Didn't return calls
Whatcom Builders, Inc.	Bellingham	Didn't return calls
Wilder Construction Company	Everett	Interested – Use recycled asphalt paving
Woodworth & Company, Inc.	Tacoma	Interested – Pierce County Health Department suspended their permit to grind asphalt shingles

Additional Sources

Matthews, Chuck. Washington State Department of Ecology Beneficial Use Program. Personal Communication, 12/6/06.

Public agencies in other states

We interviewed three national experts who are trying to promote the use of tear-off shingles in hot mix asphalt (HMA). We learned about the new, federal highway standard for use of tear-off shingles in hot mix asphalt (HMA). The Association of American State Highway and Transportation Officials (AASHTO) provisional standard was released in 2005. The standard is currently being revised, based on public comment. Reportedly, it will be voted on in early 2007. [§]

[§]Schroer, Joe. Missouri DOT Field Materials Manager. Personal communication, 12/12/06.

Three states, Missouri, Minnesota, and Texas, are working on developing their own state standards based on this AASHTO standard.

We have obtained the draft spec from Missouri. Their main concerns are the lower temperature melting properties and the harder grade of asphalt in shingles.[§]

Minnesota has conducted trials in the past on the level of contamination and on the properties of the aged asphalt in the tear-off shingles. They are in the process of further lab tests that they expect to finish next spring. They are currently working with a local county government who is interested in incorporating tear-off shingles into pavement for a bike path. Although the State DOT has approved the use of manufactured shingle scrap in asphalt paving, the use is mainly centered in the metropolitan area since that is where asphalt manufacturers are located. [‡]

[‡]Olson, Roger. Minnesota DOT Materials Research Engineer. Personal communication, 12/13/06.

Texas DOT conducted trials in 1997-99, but there was little interest from industry so the efforts were tabled even though the tests were successful. They are currently waiting on two local manufacturers for samples of material that they can test in their labs. The City of El Paso has their own tear-off shingle spec. Texas DOT engineers, reportedly, are comfortable with the use of this material, but need the data from their own labs before moving forward. Asphalt shingle manufacturing scrap has been approved for use in paving there since March 2006.[†]

[†]Raine, Woody. Texas DOT Recycling Manager. Personal communication, 12/13/06.

In early 2006, EPA awarded a grant to the Construction Materials Recycling Association (CMRA) to study the barriers to the recycling of tear-off asphalt shingles. The project has three primary objectives:

- "demonstrate successful and appropriate environmental and worker health protection procedures;
- document engineering benefits and methods of QA/QC to optimize their pavement performance specs; and
- develop operation guidelines that maximize cost-efficiency while attaining minimum environmental, worker health and safety, and engineering standards." [*]

[*] Krivit, Dan. "Mixed Messages," Construction *&* *Demolition Recycling*, July 2006.

Additional Sources

Krivit, Dan. Dan Krivit and Associates. Personal communication, 11/20/06.

Krivit, Dan. Dan Krivit and Associates. Personal communication, 11/30/06.

Melton, Dr. Jeffrey. University of New Hampshire Recycled Materials Resource Center (RMRC). Personal communication, 11/17/06.

Turley, William. Director, Construction Materials Recycling Association (CMRA). Personal communication, 12/6/06.

Shinglerecycling.org, accessed November 2006.

Step 2: Research existing processing capacity

We interviewed potential asphalt shingle processors including CDL Recycles, Recovery 1, Marathon Wood, American Roofing Recyclers (ARR), and Woodworth to determine their level of interest in collecting or processing this material. All were interested in participating in this market, through either collecting or grinding shingles.

Additional Sources

Grisham, John. Woodworth & Company, Inc. Personal communication, 11/16/06.

Grisham, John. Woodworth & Company, Inc. Personal communication, 12/4/06.

Gillis, Terry. Recovery 1. Personal communication.

Martin, Chris. CDL Recycles. Personal communication, 12/4/06.

Reykdal, Merv. American Roofing Recyclers (ARR). Personal communication, 12/4/06.

Reykdal, Merv. American Roofing Recyclers (ARR). Site visit, 12/7/06.

Yeasting, John. Marathon Wood Recovery. Personal communication.

MEMORANDUM

Date: Thursday, October 4, 2007

To: Project Stakeholders

From: Kris Beatty, King County Solid Waste Division, LinkUp program manager on behalf of the LinkUp Shingles in Paving Demonstration Project Team

Subject: Recycled Asphalt Shingles in Hot Mix Asphalt Research**:** Summary of Relevant Projects

Background

The project team committed to providing a written summary of shingles recycling research as one of the outcomes of the August 21, 2007 *King County LinkUp Shingles in Paving Demonstration Project* stakeholders meeting. This memo outlines key research findings about shingles recycling, summarizes select demonstration projects, and identifies next steps to help further disseminate relevant resources to stakeholders throughout this project.

The *LinkUp Shingles in Paving Demonstration Project* is a continuation of research on opportunities for growth in shingles recycling. King County LinkUp has been conducting research and connecting with experts to identify new opportunities and markets for recycling tear-off asphalt shingles. The objective of the current 2007/2008 project is to champion the development of a hot mix asphalt (HMA) end-market for tear-off shingles by conducting a paving trial in the Puget Sound area that incorporates this material.

King County LinkUp is maintaining a project Web page at: http://www.metrokc.gov/dnrp/swd/linkup/shingles/index.asp. This Web page currently includes links to several King County background documents:

- *Waste Monitoring Program Market Assessment of Construction and Demolition Waste Materials.* Final Report (2004). Section 3.3. Asphalt Shingles Current Supply. Prepared by Cascadia Consulting Group, Inc. http://www.metrokc.gov/dnrp/swd/about/documents/C-D_Markets_report-final.pdf

- *Increasing recycling of tear-off asphalt shingles nationwide* (Spring 2007) in the LinkUp program's quarterly newsletter, *e-Newslink*: http://www.metrokc.gov/dnrp/swd/linkup/documents/eNewslink_Spring-2007.pdf

Project Stakeholders will be notified when additional research documents are posted on the Web page. Also, King County LinkUp is maintaining a "LinkUp Blog" at http://www.metrokc.gov/dnrp/swd/linkup/blog.asp?ID=19&CatID=8 where news and updates on King County LinkUp focus materials, including asphalt shingles, are posted. Users are invited to comment on blog entries.

Summary of Shingles Research

There is a rich and deep history of research and development on the emerging technology of using recycled asphalt shingles (RAS) as a road construction material supplement. The body of published literature extends from the mid 1970's. The literature includes both government research publications and private reports and patent applications. For links to many of the past shingles recycling studies, reports and articles in trade publications, please see the following links:

- www.ShingleRecycling.org
- http://shinglerecycling.org/index.php?option=com_content&task=view&id=52&Itemid=76

As shown in Table 1, the practice of using manufacturers' RAS in hot mix asphalt (HMA) is now accepted in 15 states, of which 11 have state DOT materials specifications. Tear-off shingles are allowed in three states' DOT specifications. Six states have beneficial use determinations (BUDs) issued by their environmental agencies to allow tear-off shingles in HMA or other specified construction applications. BUDs are a regulatory tool used by state environmental agencies to help guide the approval process for proposed reuse, recycling and recovery projects.

Table 1. Recycled Asphalt Shingles: State DOT Specs and BUD Approvals

State	State DOT Specs	RAS Type	State BUD License	RAS Type
Only Manufacturer Scrap Allowed				
DE			BUD for M scrap	M
IN	5% M scrap only	M		
NC	5% M scrap only	M		
NJ	5% M scrap only	M		
PA	Provisional Spec P—c04031A	M		
TX	M scrap only	M		
VA	Special provision	M		
Tear-off Scrap Allowed				
CT			General BUD permit for recycling and storage of tear-off scrap	T
GA	5% M or T scrap	M, T		
MA	5% M scrap	M	MA BUD for M or T scrap	M, T
ME			BUD for T scrap	M, T
MN	5% M scrap only	M	BUD permit by rule for both M and T	M, T
MO	5% M or T scrap	M, T		
NY			BUDs	M, T
SC	3-8% T scrap	T		

Key to type of shingle scrap allowed:

M: Manufacturers' shingle scrap is allowed / recycled
T: Tear-off shingle scrap is allowed / recycled

There are at least three dozen road construction projects that have utilized tear-off RAS. Many of these are controlled research efforts, while some are privately-owned and/or not well documented. The www.shinglerecycling.org Web site is a good resource for learning about the successes and challenges of these projects. In particular, the following links provide information on various states' field studies, as well as key technical reports and papers:

- States' experience: http://www.shinglerecycling.org/index.php?option=com_content&task=view&id=136&Itemid=118

- Technical reports and literature: http://www.shinglerecycling.org/index.php?option=com_content&task=view&id=52&Itemid=76

In the early 1990s, the Georgia Department of Transportation (GDOT) began investigating the possibility of incorporating recycled shingles into road materials. In response to a local shingle manufacturer offering material from their manufacturing process, GDOT conducted testing with this material in 1994 and 1995. The results of the study indicated that incorporating up to 5% RAS resulted in a satisfactory paving application. The study led to a specification for the use of manufacturer scrap in paving applications, and a recommendation that a specification allowing postconsumer (tear-off) shingles be developed. In 2001, a specification that allowed for the use of up to 5% tear-off or manufacturing scrap roofing shingles was approved by the State Transportation Board. Currently, two companies are known to use manufacturing scrap in asphalt paving. Although the state DOT specification allows for the use of tear-off scrap in paving applications, a representative from one shingles recycling company reported that tear-off shingles are not generally used because of access to an ample supply of manufacturing scrap.

Recent projects involving tear-off shingles in Minnesota, Missouri and South Carolina have been selected for a more detailed review in this memo and are presented below. These are the states with active, regular paving projects or research studies using tear-off RAS into HMA for road construction. Table 2 at the end of this memo highlights select projects from these states. These studies were all conducted within the past three years, focus on tear-off shingles, involve both lab and field components, and have corresponding HMA pavement construction projects. In part as a result of their in-depth experiences, both the Missouri and Minnesota Departments of Transportation are part of a three-state task force (also including Kentucky DOT) that is reviewing the current asphalt shingle related specifications of the American Association of State Highway and Transportation Officials (AASHTO) and will soon be making recommendations for improvements.

AASHTO

AASHTO published a new provisional specification and recommended practice for shingle recycling into HMA in July 2006. This culminated a substantial amount of recycled shingles specification development work supported in part by the Recycled Materials Resource Center (RMRC). One objective of the AASHTO provisional specification and practice is to address the needs for quality assurance / quality control (QA/QC) during the processing and utilization of recycled asphalt shingles in HMA. The AASHTO standard and practice provide detailed technical guidance including:

- Types, definitions, sources, and sampling
- Gradation of RAS
- Addition rates of RAS into HMA
- Deleterious substances
- Methods of sampling and testing

The LinkUp Shingles in Paving Demonstration Project will continue to monitor the development and adoption of ongoing revisions to the AASHTO shingle recycling provisional specification and recommended practice. As indicated above, a three-state DOT task force (MN, MO and KY) is currently preparing a report on their review of the current AASHTO standard and practice. This task force will likely recommend changes to the AASHTO standard and practice that will be presented to the AASHTO committees in the spring of 2008.

CMRA

Several projects by the Construction Materials Recycling Association (CMRA), in collaboration with the U.S. Environmental Protection Agency (U.S. EPA), are currently underway to help develop the market for recycling of asphalt shingles. One of the CMRA projects is near completion and was funded in part by a grant from the U.S. EPA's Office of Solid Waste and Emergency Response (OSWER) Innovations Workgroup. The primary goal of this project is to develop, demonstrate and document best practices that can be utilized by shingle recycling operators.

Dan Krivit and Associates is writing a *Best Practices Guide* as one of three CMRA products. A second report, titled *Environmental Issues Associated with Asphalt Shingle Recycling,* is being written by Innovative Waste Consulting Services, LLC and produced by CMRA. The Web page, www.ShingleRecycling.org, is an ongoing project of the CMRA and will post these additional shingles recycling publications by November 2007.

Minnesota, Missouri and South Carolina Research Projects

Minnesota

The Minnesota Department of Transportation (Mn/DOT) has been one of the leaders in the research and development of RAS as a supplement in HMA. The Turgeon (1991), Newcomb (1993), Newcomb (2003), and Janisch (1996) studies are some of the most relevant government lab and field research published on this topic. These laboratory and field investigations, sponsored by Mn/DOT and the Minnesota Office of Environmental Assistance (MOEA), led to the development of a Mn/DOT construction material specification, originally adopted in 1996, for the recycling of manufacturers' shingles scrap into HMA. The Mn/DOT-sponsored field demonstrations using RAS in HMA pavements date back to 1990. Recent informal evaluations have indicated that these earlier shingle-derived pavement test sections were performing at least as well as the control sections without shingles.

Most recently, Ramsey County in Minnesota initiated a paving demonstration project for a pedestrian/bike trail in Maplewood, Minnesota. The project specifications approved by Mn/DOT called for a 5% mix of tear-off shingles in the HMA and the County received multiple bids for the project. The contractor has been selected, a supply of tear-off shingles has been secured, grinding and screening is scheduled for October 11, 2007, and paving is scheduled for mid October. Results from the research study will be forthcoming.

Mn/DOT has been involved with two additional recent shingles recycling demonstration projects: the *Dakota County / MOEA Lab Study* (2004 – 2006) and the *Hassan / Omann Study* (2006 – 2007). The *Hassan / Omann Project* used both manufacturers' and tear-off recycled asphalt shingles (RAS) at 5% and 10% of the total mix. No recycled asphalt pavement (RAP) was included. The demonstration included RAS in both the wear and base course. All but one of the test mixes used the "standard" virgin asphalt binder performance grade (PG) of PG 58-28. In one of the mixes, the virgin binder asphalt cement (AC) was adjusted to one grade softer to PG 52-34. The pavement test strips were constructed in August 2006 and visual inspections conducted since then indicate no performance differences to-date. The lab results are extensive, although yet unpublished, and include the following selected, tentative conclusions:

- It is difficult to interpret results to the point of firm conclusions because of limited number of samples and complex, multiple variables affecting HMA performance.
- The impacts of adding RAS, including the interactions with virgin aggregate and virgin binder, is still not well understood.
- Low temperature and fatigue cracking is most likely the property that will control the performance of HMA amended with tear-off RAS.
- The relative impacts of tear-off vs. manufacturers' RAS on the PG grade were about the same at the 5% RAS level.
- The high temperature critical performance of the HMA samples increased (i.e., improved) with the increasing amount of RAS in the mix and more so with tear-offs compared to manufacturers' shingles. The low temperature critical performance of the HMA samples increased (i.e., worsened) with the increasing amount of RAS in the mix and more so with tear-offs compared to manufacturers' shingles. The impacts of tear-off RAS on the PG grade at the 10% RAS level was about:
    - High temperature = 2 ½ grades
    - Low temperature = ½ grade
- Adjusting the virgin asphalt binder to the softer, PG 52-34, decreased both the high temperature and low temperature by ½ grade. The resulting final mix, with the adjusted, softer virgin binder, was close to original, targeted mix design PG 58-28.
- The amount of deleterious material (using the AASHTO method) varied considerably from one sample to the next. The material was primarily plastic and paper. The results ranged from about 0.03% to 0.21% with no readily apparent trend.

The following links offer further details on the *Hassan / Omann Project*:

- **Dan Krivit and Associates** (May 31, 2007) *"Recycled Tear-off Shingles Road Construction Demonstration in the Town of Hassan"* Final report to the Minnesota Local Road Research Board: http://shinglerecycling.org/images/stories/shingle_PDF/final%20lrrb-opera%20report%20hassan-omann%20demonstration%205-31-07.pdf

- **McGraw**, Jim, Mn/DOT (July 11, 2007) Power Point presentation at the *Hassan / Omann Project* luncheon meeting. http://shinglerecycling.org/images/stories/shingle_PDF/hassan%20twp%20shingle%20study%20jm%2007.07.pdf

- **Marasteanu**, Mihai, University of Minnesota, Department of Civil Engineering, (July 11, 2007) Power Point presentation at the *Hassan / Omann Project* luncheon meeting. http://shinglerecycling.org/images/stories/shingle_PDF/hennepin-07.07-shingles%20mm.pdf

The *Dakota County / MOEA Lab Analyses Project* was funded by the Minnesota Office of Environmental Assistance (MOEA). This project directly complemented a parallel study sponsored by the Missouri Department of Transportation (MoDOT). (See MoDOT project description below.) The pavement test sections were constructed in the fall of 2005 with tear-off RAS used in the base course only (i.e., no shingles were used in the surface wearing course). The tear-off pavement test sections show no observable difference compared to the control pavement sections with manufacturers' RAS and no shingles (RAP only). Lab results were reported by Mihai Marasteanu (July 12, 2006) and Jim McGraw (July 12, 2006). In summary, the impacts on mix design due to addition of tear-offs RAS showed little to no significant difference compared to the manufacturers' RAS. The principal concern was the potential for negative impact of tear-off RAS on the low temperature cracking as reported by Marasteanu.

The following links offer further details on the *Dakota County / MOEA Lab Analyses Project*:

- **Krivit**, Dan, "Shingles Recycling: Co-Sponsors Who's Who", Meeting/Workshop, July 12, 2006.

- **Marasteanu,** Mihai; Zofka, Adam, "Summary of Shingle Work at the University of Minnesota", University of Minnesota, Civil Engineering Department, July 12, 2006.

- **McGraw**, Jim, "Mn/DOT Shingle Study", Minnesota Department of Transportation, Materials Research Lab, July 12, 2006.

- **Schroer**, P.E. Joe, "Asphalt Shingles in HMA Missouri DOT Experience", Missouri Department of Transportation, Construction and Materials Division, March 30, 2005.

Missouri

The Missouri Department of Transportation (MoDOT) adopted an HMA materials specification that allows both manufacturers' shingle scrap and tear-off shingle scrap. The MoDOT specification was issued in 2005 and was the result of field pavement testing and lab research. Results indicate a very durable, more-rut resistant asphalt at a lower cost. Research and development has continued since that time with three contractors in Missouri submitting mix designs for regular paving projects as per the requirements of the state DOT specification. The

standard virgin binder performance grade (PG) for traditional HMA mixtures in Missouri is PG 64-22. The MoDOT specification was developed with the intent that at 5% tear-off RAS in the HMA mix, the mix design with shingles must be adjusted to incorporate a "softer" virgin binder. HMA with 5% shingles must use a virgin binder that is one grade softer from the traditional grade. This softer virgin binder of PG 58-28 must be used unless additional test results could support alternative mix design plans. Based on this specification and additional testing, MoDOT has allowed up to 2% RAS in PG 64-22 HMA without adjusting the virgin binder with a softer grade.

South Carolina

The South Carolina Department of Transportation co-sponsored a study in April 2001, *Field Evaluation of Use of Waste Shingles in Asphalt Mixtures*, by SN Amirkhanian and KM Vaughan from Clemson University. Approximately one mile of road section (two lanes) was paved using 8% tear-off RAS in the HMA surface course. Relatively few problems were encountered during the production and placement process. Subsequent testing of the in-place cores indicated that all test properties were satisfactory. Rideability (smoothness) results, although within specifications, were somewhat worse for the mix containing shingles than for surrounding control sections. Follow-up research steps were recommended and one is underway.

The 2001 Amirkhanian study lead to a SCDOT specification allowing manufacturers' or tear-off RAS into HMA in the range of 3% to 8%. Ashmore Brothers, Inc. is the primary contractor that regularly uses tear-off RAS in their HMA mixes mostly at 3%. SCDOT uses a total combined HMA mix viscosity test to determine job mix design. Ashmore is currently using a maximum of 3% tear-off RAS and zero RAP as their best means to attain SCDOT mix design standards. SCDOT approves Ashmore's mix designs and they are very pleased with the tear-off RAS HMA mixes and pavements. Ashmore uses the tear-off RAS in two of their three HMA plants in SC, and is working on introducing it into their third plant. The Ashmore HMA quality control manager reports that the tear-off RAS-derived HMA works out well with great compaction and tensile strength retained (TSR) lab results compared to traditional mixes without RAS. Ashmore has been using the tear-off RAS in the base and binder (middle) courses, but is currently working to get SCDOT approval for using it in surface course of HMA.

Conclusion

State specifications and BUDs for using RAS in paving projects are based on DOT–sponsored and other laboratory analyses. The entire body of research indicates that the benefits of using manufacturer's RAS in traditional HMA may include:

- Potential to enhance densification.
- Felt-backed RAS does not negatively influence moisture sensitivity at low percentage blends (5% or less of RAS in the mix).
- The grade of asphalt cement used in shingles is, in general, much harder than standard grades of asphalt used in traditional HMA pavement mixes. This difference in asphalt grade has advantages (e.g., potential for reduced rutting) and disadvantages (e.g., potential for increased low temperature cracking).

- Permanent deformation (i.e., rutting) characteristics can be improved when blended in to HMA using a softer virgin asphalt binder.

- Potential to reduce costs of virgin asphalt binder by partial replacement with the RAS binder. In general, felt-backed shingles will have more asphalt cement content than fiberglass-backed shingles.

Laboratory analyses indicate that the disadvantages of using manufacturer's RAS in traditional HMA may include:

- Fiberglass-backed RAS may increase moisture sensitivity especially at higher levels of RAS (10% or greater), but there is little impact on resilient modulus.

- Cold tensile strength is reduced (leading to an increased potential for cold temperature or fatigue cracking) depending on type of shingles (felt vs. fiberglass, manufacturer's vs. tear-off).

The research and materials specifications for recycling of shingle scrap into HMA are built upon the successful development of the RAP technology. Some state DOT specifications allow a maximum of 20 to 30 percent RAP depending on the type of mix and pavement traffic conditions. According to the Mn/DOT bituminous HMA specifications, RAS is considered a type of RAP for purposes of calculating the maximum amount of recycled product.

The technical engineering and economic feasibility of recycling shingle scrap is dependent on adequate material QA/QC procedures. These QA/QC procedures are needed throughout the entire recycling operation in each component of the system. It is imperative that a high quality RAS product be reliably produced from the shingle recycling operation. Also, the supply of scrap feedstock should come from known, certified sources.

There is general consensus that the relative amount of manufacturers' RAS in HMA should remain at a 5 percent maximum by weight of aggregate using standard mix design and virgin asphalt binders. This standard 5 percent level provides an optimum balance between maximizing the benefits of adding RAS while minimizing any potential negative impacts on pavement performance.

The industry is moving towards calibrating more precisely the optimum amount of RAS to be included in a mix using more sophisticated lab analyses and engineered mix designs. This may include corresponding adjustments to the virgin asphalt binder performance grade (PG).

The primary economic driver in this technology is the proven, significant cost savings in partial replacement of virgin asphalt binder. The value of shingles recycling will increase proportionally to the price increases of virgin asphalt cement. Secondary economic drivers may include: avoided cost of landfill tipping fees; partial replacement of virgin aggregates; and the added fiber content.

Testing for Effects on HMA Pavement Performance and Mix Design

In general, the HMA that contains RAS should meet or exceed the normal state QA/QC requirements for traditional HMA. Many state DOTs require the following tests as part of normal

QA/QC procedures for HMA specifications: tensile strength retained (TSR); air voids of the HMA mix (as sampled behind the paver before compaction); in place density (after compaction); and final inspection after pavement installation of cracking and other visual observations.

Methods of sampling and testing should be planned as part of any shingles recycling research project. Researchers should plan to sample at each step in the shingle recycling / HMA process including RAS pile, RAP pile, loose HMA behind the paver, and final cores after compaction.

The following parameters have been studied by a variety of shingles recycling research projects and should each be carefully considered when planning for additional research: asphalt cement (AC) content in the RAS, RAP and final HMA mix; performance grade (PG) of the final HMA mix; gradation of RAS; gradation of the final HMA mix; mix ratio of RAS; and deleterious substances.

Several additional shingles recycling research questions have been studied to further examine the impacts of RAS on the HMA pavement and mix design. These additional research parameters and tests have included: binder extraction; asphalt cement performance grade (PG); bending beam rheometer (BBR); and indirect tensile strength (IDT) tests. These are not traditional tests and, in general, are not normally required as part of state DOT regular QA/QC procedures. Academic institutions with more advanced laboratory research procedures have partnered with state DOTs and other project operators to conduct these additional tests.

Health and Safety of Employees at the Shingle Recycling Plant

Shingle recyclers must strive to maximize the protection of the health and safety of their workers at all stages including system planning, design, construction, ongoing operations, and marketing. It is important to note that these workplace risks will be negligible if best practices are implemented and the overall recycling system QA/QC plan and implementation is thorough.

The employee hazard prevention plan should include best available information about asbestos and other dust management and exposure prevention similar to the types of information provided on the ShingleRecycling.org Web site. Shingle plant operators that are fully informed and trained will be the company's most important strategy to safely produce a high quality product free of any asbestos risks. Employees will be the first line of quality assurance from every step such as feedstock quality control (e.g., rejecting unacceptable loads), through dust management during grinding (e.g., maintaining optimum grinding conditions), to RAS product sampling.

Road Safety

The state DOTs that have studied asphalt shingle use in paving projects have not identified road safety performance as an issue. However, the importance of the recycled asphalt shingles (RAS) to be free of contaminants, such as nails, is critical for both worker safety and road safety.

Environmental Impacts

Shingle recycling systems should be planned, designed and implemented to fully comply with or exceed all waste disposal regulations. Asbestos management plans must be developed in

accordance with federal NESHAP asbestos regulations as promulgated by the U.S. EPA. NESHAP is administered and enforced by the state environmental agency.

The vast majority of tests conducted on asphalt shingles have found no asbestos. But some types of other asphalt roofing products, such as roll roofing, adhesives, paints or waterproofing compounds may contain asbestos. Several states have worked with recyclers to conduct initial testing on their waste stream to demonstrate the safety of their operation.

Results of past asbestos sampling studies were summarized as part of the ongoing "Asphalt Roofing Shingle Recycling Assessment Project" (ARSRAP). Dr. Timothy Townsend, et. al. (Innovative Waste Consulting Services, LLC) recently updated the summary and analysis of this ARSRAP data in a separate document entitled "Environmental Issues Associated with Asphalt Shingle Recycling".

The ShingleRecycling.org Web page is a key portal to a significant amount of EPA and other regulatory information about asbestos regulation, management and other recommended best practices. It is up to the recycler to determine the specific state and local regulations that may apply.

Ongoing Information Dissemination

A number of next steps are anticipated to continue the dissemination of research and other technical assistance resources.

- LinkUp Shingles in Paving Demonstration *Project Stakeholders* and other interested parties can check the Project Web page regularly for new information about the project. The project team will notify Stakeholders when the links to the documents mentioned in this memo are included on this Web site.

- *Project Stakeholders* can browse an extensive list of literature resources on asphalt shingle recycling, including technical reports, articles, fact sheets, and presentations, with document links where possible, at http://shinglerecycling.org/index.php?option=com_content&task=view&id=52&Itemid=76.

- *Project Stakeholders* and other interested parties should consider attending the *3rd Asphalt Shingle Recycling Forum* in Chicago on November 1 – 2, 2007. LinkUp may consider financial assistance for selected representatives of the LinkUp Shingles Project Advisory Group to attend. For more information, link to Construction Materials Recycling Association's *3rd Asphalt Shingle Recycling Forum* Web page: http://www.shinglerecycling.org/index.php?option=com_content&task=view&id=186&Itemid=277

- The LinkUp Asphalt Shingle Project Team will soon be organizing the first meeting of the project advisory group. Meeting summaries will be posted on the Shingles in Paving Demonstration Project Web site.

Table 2. Key Findings of Select Shingle Recycling Projects

Project Title	Type of Project	Primary Sponsor	Secondary Sponsor	Dates	Type of RAS	Contacts	Current Status	Key Findings
Ramsey County Lower Afton Trail (LAT)	Pedestrian / Bike Trail	Ramsey County, MN	Mn/DOT	2007	T	Bob Paine, Ramsey County Dept. of Public Works	Project specifications written and released. Bids received from multiple contractors. Contract awarded to Rachel Construction (primary). Rachel subcontracted with Midwest Asphalt for paving / HMA production. Shingles "grinding" scheduled for early October 2007.	*Study is in beginning stages. No findings at this time.*
Hassan / Omann	Rural township road. Formerly aggregate surface, paved with HMA test strips.	SWMCB, Hennepin County, Mn/DOT	U of MN Dept. of Civil Engineering, Town of Hassan, Omann Brothers Inc., Dakota County, LRRB, DKA	2006-2007	M, T	Dan Krivit and Associates. Mn/DOT. U of MN. Hennepin County.	Multiple funding sources secured, paid in early to mid 2006. Final project meeting held on July 11, 2007.	U of MN testing: Inconclusive results on HMA low temperature and fatigue cracking impacts as measured in the lab using the indirect tensile (IDT) strength test; 10% tear-off RAS result in greater creep stiffness compared to the same mix using manufacturers' RAS. Mn/DOT lab results: The percent AC and PG grade in the final HMA core samples varied by mix type and amount of RAS used in the mix; the relative impacts of tear-off vs. manufacturers' RAS on the PG grade were about the same at the 5% RAS level. The impacts of tear-

Key to type of shingle scrap used:
M: Manufacturers' shingle scrap was used
T: Tear-off shingle scrap was used

Project Title	Type of Project	Primary Sponsor	Secondary Sponsor	Dates	Type of RAS	Contacts	Current Status	Key Findings
								off RAS on the PG grade at the 10% RAS level was about 2½ grades at the high temperature and ½ grade at the low temperature. Adjusting the virgin asphalt binder to the softer PG 52-34 decreased both the high temperature and low temperature by ½ grade. The resulting final mix, with the adjusted, softer virgin binder, was close to original, targeted mix design PG 58-28. Many more parameters tested.
Dakota County MOEA Lab Study	County Road / State Aid Highway arterial.	MOEA (now MPCA); Dakota County	Mn/DOT; U of MN Dept. of Civil Engineering, Bituminous Roadways Inc.	2004-2006	M, T	Dan Krivit and Associates. Mn/DOT. U of MN. Dakota County.	MOEA funding secured in 2004. Project paved in 2005. Lab work in 2005 - 2006. Final project meeting held on July 12, 2006.	U of MN testing showing potential for tear-off RAS to cause increased low-temperature cracking on HMA. Mn/DOT lab results: Consistent AC content within tear-off RAS averaged about 30%.
MoDOT Lab Study	More than one type.	MoDOT	Pace Construction Inc.	2004-2006	M, T	Joe Schroer	Mo/DOT and Pace Construction collaborated with Mn/DOT and U of MN to conduct IDT tests in 2005.	Mo/DOT's specification for use of tear-off shingles in HMA at up to 5% with adjusted virgin binder PG grade verified by U of MN strength and creep tests using IDT.

Key to type of shingle scrap used:
M: Manufacturers' shingle scrap was used
T: Tear-off shingle scrap was used

Project Title	Type of Project	Primary Sponsor	Secondary Sponsor	Dates	Type of RAS	Contacts	Current Status	Key Findings
MoDOT Mix Design Approval	More than one type.	MoDOT	Jornagen Construction Inc. and two additional contractors	2005 – 2007 (ongoing)	M, T	Joe Schroer	Mo/DOT has worked with two additional contractors in 2007 to approve mix designs per Mo/DOT spec. Contractors are using 2% RAS of tear-off shingles to avoid added costs of adjusting AC virgin binder.	*Study is in beginning stages. No findings at this time.*
SCDOT mix design approval	HMA in road construction: base and binder courses	SCDOT	Ashmore Brothers, Inc.	2005 – 2007 (ongoing)	T	Cliff Selkinghaus, SCDOT Stewart Boone, Ashmore	Ashmore is the primary contractor that regularly uses tear-off RAS in their HMA mixes mostly at 3%.	SCDOT uses a total combined HMA mix viscosity test to determine job mix design. Ashmore is currently using a maximum of 3% tear-off RAS and zero RAP as their best means to attain SCDOT mix design standards. SCDOT approves Ashmore's mix designs and they are very pleased with the tear-off RAS HMA mixes and pavements. Ashmore uses the tear-off RAS in two of their three SC HMA plants. Working on introducing it into their third plant. Tear-off RAS- derived HMA works out well. Compaction is great. Often better TSR results compared to traditional mixes without RAS. Working to get SCDOT approval for use of tear-off RAS in surface course of HMA.

Key to type of shingle scrap used:
M: Manufacturers' shingle scrap was used
T: Tear-off shingle scrap was used

MEMORANDUM

Date: Tuesday, December 30, 2008

To: Kevin Kelsey and Rick Brater;
King County Department of Transportation (KCDOT)

Cc: Jim Eagan, Frank Overton, Alan Corwin; KCDOT
Joe DeVol, Washington Department of Transportation

From: Michelle Caulfield; Cascadia Consulting Group
(On behalf of Kris Beatty; King County Solid Waste Division (KCSWD) and the *LinkUp* Shingles in Paving Demonstration project team)

Subject: King County's Shingles in Paving Demonstration Project:
Preliminary Response on Long-Term Pavement Performance and Safety Issues

BACKGROUND

King County Department of Transportation (KCDOT) staff requested that the *LinkUp* project team provide information on several technical questions about the use of tear-off recycled asphalt shingles (RAS) in hot-mix asphalt (HMA). The primary concerns expressed were about long-term pavement performance and safety issues.

King County Solid Waste Division (KCSWD) has been working with KCDOT and Washington State Department of Transportation (WSDOT) throughout most of this year in the planning, development and design of the *LinkUp* recycled Shingles in Paving Demonstration Project. The detailed issues and technical information discussed within this memo should be considered within the overall project plans, stakeholder participation processes, strategies for risk management, and materials quality assurance / quality control (QA/QC) procedures.

This memo is intended to provide the *LinkUp* project team's direct response to those KCDOT technical questions as communicated in part through Kevin Kelsey's e-mail dated 12-4-2008.

STATUS OF PROJECT PLANNING TO-DATE:

Past project milestones have included:

- Formation of a technical Advisory Group (three full group meetings to date).
- Formation of a Stakeholders Group (one meeting and a series of e-mails).
- Preparation of a background research memo (October 2007).
- Draft RAS materials specification and supply requirements. (Please refer to the draft *Specifications for recycled asphalt shingles (RAS) derived from tear-off roofing scrap* for the King County Project transmitted by Frank Overton on 12-15-2008 under separate cover).

- Release of a Request for Information (RFI) and RAS samples from RAS recyclers/processors.
- Preliminary analysis by WSDOT of the preliminary RAS samples submitted in response to the RFI.
- Development of screening criteria for the selection of the specific KCDOT paving project to serve as the demonstration site. Preliminary decision by KCDOT to focus on the 2009 South Overlay Paving contract projects for the demonstration site.
- Design of preliminary pavement test section plan.
- Draft of "testing matrix" to outline the materials sampling and testing schedule (including pre- and post-pavement construction surveys).
- Draft HMA specification. WSDOT is in the process of drafting the provisional HMA specification for the King County project, including mix design. This mix design will be finalized after the contractors are selected and the final materials are tested for verification.

KEY TECHNICAL ISSUES

1. What public agencies have used RAS and RAP in combination with HMA for an overlay program and were they used as the wearing course? If so, how long and how well has this product performed from a structural standpoint? What are the risks using this product from a structural standpoint?

There are now five state Departments of Transportation that have adopted permissive materials specifications allowing the use of tear-off recycled asphalt shingles (RAS) in the hot-mix asphalt (HMA): **Alabama, Georgia, Missouri, South Carolina**, and **Wisconsin**. Ten (10) other states' DOT's have allowed the use of manufacturers' RAS, made from asphalt shingle manufacturing waste. (See Attachment 1 – List of State DOT's Allowing RAS in HMA.) Dozens of paving projects have been successfully constructed using RAS in the wear course asphalt for both overlay and new construction/reconstruction projects in these states. These states all allow and frequently use RAP with RAS.

The Project Team was not able to determine for this memorandum if most projects reviewed were overlay or new construction/reconstruction. This information could be gathered with additional time and specific direction. However, it is our opinion that for the technical issues raised, RAS modified HMA pavement will likely perform the same in the wear course whether in overlay or new construction/reconstruction. Similarly, it is reasonable to assume that the relative difference in behavior and performance of manufacturers' and tear-off RAS in HMA is not significant. The transportation pooled fund study *Performance of Recycled Asphalt Shingles in Hot Mix Asphalt* study (2008-2010) is just getting underway to examine any specific behavior and performance differences of tear-off shingles in HMA. This study is sponsored by MoDOT with the participation of CA, CO, IA, IN, MN, MO. For more information, go to http://www.pooledfund.org/projectdetails.asp?id=1208&status=1.

Missouri has the largest number of known HMA producers / paving companies utilizing RAS-derived asphalt, and the largest number of known shingle processors providing recycling services and RAS product to HMA producers. In 2008, tens of thousands of tons of tear-off RAS were produced and used in hundreds of thousands of HMA. The early adoption of a permissive tear-off specification by Missouri Department of Transportation (MoDOT) is one reason for such a high level of shingles recycling activity in that state. The MoDOT specification allows up to 7% tear-off or manufacturers' RAS, with a virgin binder "trigger" set at 70% minimum before the virgin binder PG must be adjusted to a softer grade. (See Attachment 2 – MoDOT Materials Specification Allowing RAS in HMA.) Known HMA producers in Missouri using tear-off RAS in the commercial mixes include:

APAQ – Missouri
Blevins Asphalt
Christensen Asphalt
G & M Asphalt
Hutchens Construction
Jefferson Asphalt
Journagan Construction
NB West Construction
Pace Construction
Superior Bowen Construction
Swift Asphalt Paving
Willard Asphalt

Wisconsin Department of Transportation (WisDOT) recently announced their HMA recycled asphaltic materials (RAM) specification which allows for the use of tear-off RAS, effective January 1, 2009. The WisDOT approach is similar to MoDOT and AASHTO but regulates the maximum binder from RAM and not the minimum virgin binder. The WisDOT specification provides for a maximum allowable percent binder replacement from RAM. For example, mixtures with both RAS and RAP have a maximum allowable binder replacement of 30% from the RAM on lower layer (base course) mixes and 20% on upper layer (wear course) mixes. (Attachment 3 – WisDOT Recycled Asphaltic Materials Specification Allowing the Use of RAS in HMA). Known HMA producers in Wisconsin either currently using RAS in commercial mixes or gearing up to do so under the new 2009 specification include:

Allied Blacktop & Paving
B.R. Amon and Sons
Mathy Construction
Payne & Dolan
Tri-County Paving

In **South Carolina**, the South Carolina Department of Transportation (SCDOT) co-sponsored a study in April 2001, *Field Evaluation of Use of Waste Shingles in Asphalt Mixtures*, by SN Amirkhanian and KM Vaughan from Clemson University. Approximately one mile of road section (two lanes) was paved using 8% tear-off RAS in the HMA wear course. Relatively few problems were encountered during the production and placement process. Subsequent testing of the in-place cores indicated that all test properties were satisfactory.

The 2001 Amirkhanian study lead to a SCDOT specification allowing manufacturers' and tear-off RAS into HMA in the range of 3% to 8%. Ashmore Brothers, Inc. is the primary contractor that regularly uses tear-off RAS in their HMA mixes mostly at 3%. SCDOT uses a total combined HMA mix viscosity test to determine job mix design. Ashmore is currently using a maximum of 3% tear-off RAS and zero RAP as their best means to attain SCDOT mix design standards. SCDOT approves Ashmore's mix designs and they are very pleased with the tear-off RAS HMA mixes and pavements. Ashmore uses the tear-off RAS in two of their three HMA plants in SC, and is working on introducing it into their third plant. The Ashmore HMA quality control manager reports that the tear-off RAS-derived HMA works out well with great

compaction and tensile strength retained (TSR) lab results compared to traditional mixes without RAS. Ashmore has been using the tear-off RAS in the base and binder (middle) courses and was working to get SCDOT approval in 2007 for using it in wear course of HMA. The LinkUp Team was not able to reach SCDOT staff to learn about wear course efforts in time for the submittal of this memorandum.

In **Minnesota,** the Minnesota Department of Transportation (Mn/DOT) has had a materials specification allowing the use of 5% manufacturers' RAS in HMA since 1996. When manufacturers' RAS is used in the HMA mix, Mn/DOT's specification sets a 70% minimum new asphalt binder of the total binder on the higher traffic volume highways. Recently, Mn/DOT's Bituminous Engineer also proposed that the new asphalt binder must be at least 3.5% of the total mix when RAS is used as part of the allowable RAP percentage. (See Attachment 4). The Mn/DOT specification was based on a series of research studies (sometimes referred to as Mn/DOT's "Phase One" research) including multiple field pavement demonstrations and lab analyses. [(a)] Three of these original Mn/DOT – sponsored projects involved HMA wear course field demonstrations using manufacturers' RAS:

- Munger Recreation (Bicycle / Pedestrian) Trail in St. Paul (paved in 1990)
- Trunk Highway (T.H.) 25 in Mayer , MN (paved in June, 1991)
- County State Aid Highway (CSAH) 17 (circa 1991)

More recently, there are eight known demonstration projects (involving at least six different paving contractors) in Minnesota that have successfully used tear-off RAS in the wear course of HMA paving projects and two more are planned for 2009:

- City of St. Paul (Westminster Street) / Bituminous Roadways, Inc. as part of the Recycled Materials Resource Center (RMRC) – funded study (paved in October 2003)
- Dakota County / Bituminous Roadways, Inc. as part of the MOEA Lab Analyses Project (2005 – 2006) *
- Hassan Township / Omann Brothers, Inc. Project (August 2006) *
- Ramsey County Lower Afton Trail / Midwest Asphalt / Omann Brothers (November 2007) *
- Midwest Asphalt – private job (November 2007) *
- Shamrock Recycling / Commercial Asphalt – private job (2008) *
- Hennepin County overlay demonstration / Knife River / Omann Brothers (August 2008) *
- Dem-Con / Commercial Asphalt shingle recycling demonstration (October 2008) *
- Dakota County Mississippi River Trail project (To be installed in 2009 - paving contract not yet awarded)
- St. Louis County / Mesabi Bituminous Inc. (demonstration paving project to be installed in spring of 2009)

Mn/DOT is in the middle of a lab study to develop a new permissive tear-off RAS specification that will soon have interim data results. Mn/DOT also has authorized provisional project specifications allowing use of tear-off RAS in HMA (including in the wear course) on an individual, job-by-job approval basis. Mn/DOT intends to have a permissive tear-off RAS specification for use in HMA by October 1, 2009.

Structural Integrity Risks

The general consensus of most HMA producers using RAS in their asphalt mixes and state DOT engineers researching this issue is that the principle concern about pavement structural integrity is the stiffer grade of asphalt binder used in shingles. This difference in grade of binder must be accounted for in the mix design to help mitigate against risk of premature cracking. Reducing the maximum amount of tear-off RAS to 3% by weight of total aggregate in the mix is the first strategy. Adjusting the virgin binder to a softer grade to compensate for the harder grade in shingles is an optional, secondary mix design strategy. This issue has been studied extensively and has resulted in the current mix design limits (e.g., maximum of 3% RAS, etc.) and QA/QC recommendations (e.g., RAS gradation, moisture content, etc.).

There is still ongoing and legitimate technical debate about the impacts of the stiffer binder in shingles on the HMA mix. Also, there is ongoing discussions and research about the relative amount of effective release of the shingle asphalt binder when blended with virgin materials in the HMA drum. Many interests continue to discuss these key RAS recycling issues including bituminous pavement engineers, HMA producer practitioners using RAS, the asphalt roofing industry and the others in the shingles recycling industry.

A summary of available literature on the questions of the stiffer binder in shingles as it may impact the final HMA mix properties is under preparation by Dan Krivit, *LinkUp* consultant, for another project. One study (Gallagher, 1996 [(b)]) concluded:

> "The results of this investigation indicate that air-blown asphalts are not deficient in any way compared to conventional straight run asphalts. In fact, air-blown asphalts are generally more favorable than conventional asphalts in terms of the PG-grading system. Therefore, there is no foreseeable technical reason why air-blown asphalts should be excluded from use in paving applications where they meet the desired PG-grade."

Another, earlier study (Newcomb, 1993 [(c)]) concluded that "An improved resistance to pavement rutting due to a combination of the fibers and harder asphalt used in the shingles."

Core samples have been collected on several demonstration projects that used RAS in the HMA asphalt pavement in Missouri and Minnesota. In general, lab test on these core samples from pavement test sections provided similar results to the other tests conducted on loose HMA samples. MoDOT and Mn/DOT reports and presentations have been written that can be provided upon request.

One such Mn/DOT report (Janisch, 1996 [(d)]) states:

> "Post-construction cores were obtained from all three projects and tested in the laboratory. Cores were obtained from both the control sections and the shingle scrap sections. Extraction gradations were run on all samples, moisture sensitivity and resilient modulus testing was done on the T.H. 25 samples taken in 1992. Cores from T.H. 25 and Scott CSAH 17 were obtained in 1995 and tested for in-place air voids, A.C. content, A.C. penetration and A.C. viscosity. All of the testing was done by Mn/DOT at its Materials Research and Engineering Lab in Maplewood, Mn."
>
> "Not only are the test sections performing as well as the control sections, but using shingle scrap reduces the amount of virgin asphalt cement required in a bituminous mix,

thus creating the potential for a cost savings when using shingle scrap in HMA. Based on the performance of these test sections, shingle manufacturing scrap is now an allowable salvage material in hot mix asphalt under Mn/DOT specification."

In 2004, Mn/DOT staff conducted additional core samples on T.H. 25 and Scott CSAH-17 (paved in 1991) to determine if there was any difference in long-term wear. There was little to no significant difference in the PG grade as can be seen from the following data results:

	Percent Shingles	PG Grade
TH 25 (control)	0%	73 - 20
TH 25 (test #1)	5%	75 - 20
TH 25 (test #2)	7%	79 - 15
CSAH 17 (control)	0%	77 - 22
CSAH 17 (test)	10%	75 - 24

Mn/DOT conducted extractions on a series of four core samples on the Hennepin County France Avenue demonstration project. This was a County-installed maintenance overlay project paved in July 2002 with manufacturers' RAS. Mn/DOT conducted the extractions to measure performance grade (PG) of the in-place binder. The extraction results indicated that there was no substantial difference between the pavement mix with shingles compared to the mix without shingles. The County had specified PG 58 - 28 and core sample extraction results indicated:

On southbound lanes (30 percent RAP, no shingles):

- PG 67.6 - 27.0 (sample #1)
- PG 68.1 - 27.9 (sample #2)

On northbound lanes (25 percent RAP, 5 percent shingles):

- PG 66.5 - 27.9 (sample #3)
- PG 67.6 - 28.4 (sample #4)

Attaining in place HMA compaction density specifications has never been a problem as reported by public agencies and private paving contractors. In fact, some paving contractors have stated that attaining compacted densities is enhanced with the addition of RAS into the HMA mix and that incentive bonuses have been granted when using RAS-derived mixes.

AASHTO is currently conducing an amendment process to further refine the original provisional specifications for use of RAS in HMA. As per the original AASHTO specifications published in 2006, the 2008 amendments allow for the use of tear-off RAS in the wear course (AASHTO Designations: MP 15-08 and PP 53-08). These 2008 RAS specification amendments are currently in the final stages of the elaborate AASHTO balloting process and will help further specify definitions, limits and measurements of deleterious materials in the RAS. The 2008

AASHTO RAS specification amendments are available upon request. The requirements within the AASHTO specifications have been carefully considered by the extended King County project team including KCDOT and WSDOT.

LinkUp Efforts to Mitigate Premature Cracking & Other Risks

Kevin Kelsey's 12-4-2008 e-mail correctly states that the King County *LinkUp* project team and Advisory Group recommend "that a maximum of 3% RAS and 15% RAP by weight of total aggregate be added to the overall HMA mix for our demonstration project. The amount of (virgin liquid) binder will be adjusted to meet the virgin HMA design content." It is notable, however, that WSDOT staff will likely require a minimum amount of virgin liquid binder that will place an effective maximum on the amount to be replaced by recycled binder from the combination of RAS and RAP. This approach is similar to recent RAS mix design specifications from AASHTO, Missouri, Wisconsin and Minnesota. See the appropriate attachments for the other states DOT specifications.

We agree with Kevin Kelsey's assessment as stated within his 12-4-08 e-mail:

> "Based on these limited proportions (of RAS and RAP), we believe there is a risk that some additional fatigue cracking (could) prematurely occur… (but this) would not significantly impact the structural integrity of the roadway over the anticipated life of the pavement. It is the intent of the demonstration project to determine what impacts have occurred."

We believe that relatively minor risk of additional cracking can be substantially mitigated. This opinion is based on other states' DOT's specifications, the recent amendments to the AASHTO specifications, and the practical experience of multiple HMA producers and their customers that own the highways and other pavement projects. The extended *LinkUp* project team is working on details to implement the following package of recommendations to help mitigate any additional risk associated with using RAS:

- Limit the amount of RAS in the test mix to a maximum of 3% by weight of total aggregate.
- Limit the amount of RAP in the test mix to a maximum of 15% by weight of total aggregate.
- Require a minimum of 70% of the total binder in the text mix comes from added virgin liquid binder.
- Finalize the WSDOT–recommended mix design ASAP so that it can be reviewed and approved by KCDOT.
- Finalize the provisional RAS specification for the project that includes stringent QA/QC requirements (e.g., final RAS product: gradation, moisture, deleterious, verification as free of prohibited contaminants, etc.).
- Using RFP, select the shingle recycling processor that provides "best value" to King County as the RAS supplier, including stated willingness to meet the provisional RAS material specification.
- Verify that the final RAS product meets the materials quality specifications before the County accepts the product.

- Verify the test mix design, final project logistics, and feedstock materials after the County's shingle recycling processor is selected and South Overlay Paving contract is executed such that all HMA mix materials are known. Final project logistics plans will include production and verification testing schedules for RAS and RAP, etc.

2. Has RAS and RAP in combination with HMA been tested for skid resistance?

Our team has not yet found any skid resistance test data from other controlled research projects where RAS was used in the wear course. The *LinkUp* project team, including Joe DeVol, Bituminous Materials Engineer, WSDOT, agree with Kevin Kelsey per his 12-4-08 e-mail:

> "We would suspect, because of the limited amount of RAS (3%) used and its structural makeup (angular sands), there would be little if no change in skid resistance as compared to a conventional asphalt roadway."

As Kevin notes, the aggregates in shingles are hard, angular mineral aggregate and not silica sands used in the manufacturing of glass containers. Recycled glass is often produced by higher speed milling. Generally, the aggregates in shingles are not significantly modified (i.e., smoothed) by the grinding process. Normally, shingles processors use low-speed, high-torque shredders (i.e., modified wood chippers) for grinding shingles. Hammer mills or impact mills are generally not utilized for shingles grinding.

3. Will there be nails or other harmful objects in the mix?

Recent RAS and HMA materials specifications (e.g., MoDOT, AASHTO, provisional Mn/DOT) state that the final RAS product must be essentially free of nails. Nails that may remain intact and visible that show up into the HMA pavement are an obvious and unacceptable hazard. Therefore, the shingle recyclers have refined their processes to assure that no whole, intact nails remain in the final RAS product. Also, HMA producers often include magnetic separators on their recycled cold-feed conveyors to provide additional quality control as the RAS product is fed into their HMA plants.

In August 2008, three local RAS recyclers/processors provided *LinkUp* with preliminary samples to inform the development of the RAS specification. In its preliminary analysis of this material, WSDOT found one nail in one of the three RAS samples. While these samples were not submitted with the intention of meeting specification, the *LinkUp* project team will work with the selected RAS processor to ensure that that final RAS product meets the specification and is free of nails and extraneous waste materials. King County's RAS specification in its current draft form provides for the following extraneous requirements for the finished RAS product (Section A.7):

> "The final RAS product shall be substantially free of extraneous waste materials **and free of whole, intact nails**. Extraneous materials such as metals, glass, rubber, nails, soil, brick, tars, paper, wood and plastic shall not exceed 3.0 percent by mass as determined on material retained on the 4.75-mm (No. 4) sieve. Lighter material such as paper, wood and plastic shall not exceed 1.5 percent by mass as determined on material retained on the 4.75-mm (No. 4) sieve."

The removal of all whole, intact nails from the final RAS product is a very important standard for the King County project within the RAS specification. This is one reason why the draft RAS specification states that the County shall be allowed to take its own random samples from the finished RAS product stockpile.

4. Is there the potential for asbestos or other hazardous materials to be present in RAS?

Department of Ecology's Solid Waste and Financial Assistance Program assessed the risk associated with various reuses of asphaltic roofing materials. The assessment was based on two primary sources: sampling Ecology did of roofing materials from three different facilities in Washington in May 2007 and the Oregon Department of Environmental Quality's Staff Report on Reuse of Roofing Waste from August 2004. The testing done by Ecology found values that exceed human health or environmental protection standards for metals such as lead, copper, zinc, mercury, and arsenic, as well as benzole(a)pyrene. Because materials in both assessments tested high enough to pose a risk to human health and the environment, Ecology considers ground or shredded asphaltic roofing shingles to pose a health and environmental threat *when the materials are not sealed under or into an impervious surface*. ***Ecology found that acceptable-risk uses might include road base under an impervious surface and incorporation into hot mix asphalt.***

Ecology determined that a Beneficial Use Determination is not necessary for the use of asphalt shingles in HMA paving for the following reasons:

- The shingle material is essentially encapsulated in the pavement;
- Ecology has found no asbestos hits in its testing; and
- Polycyclic aromatic hydrocarbons (PAHs) levels are not appreciably higher than with virgin asphalt pavement.

Ecology is supporting the Shingles in Paving Demonstration Project and recently awarded the project a $75,000 grant. Ecology, Puget Sound Clean Air Agency, L&I and local health departments are all working with the *LinkUp* project team to develop RAS specifications and Invitation to Bid (ITB) language to ensure worker safety and environmental health at the RAS processing facility and the HMA plant.

Our contacts with U.S. Environmental Protection Agency (EPA) and the asphalt industry have yielded no data that suggests any problem with the threat of flame retardants in shingles posing environmental or health problems. One shingle manufacturer states that in recent memory, no added flame retardant chemicals have been used in the production of their current line of asphalt shingles. The limestone filler, however, has some flame retardant properties. Most shingle manufacturing industry representatives have stated that the detailed asphalt shingle "recipe" by individual manufacturers is proprietary / confidential information and will not be released. It is important to note that the trend to switch from organic (cellulose) felt shingles to fiber glass shingles in part addresses the risk of fire and need for ASTM standard fire resistance levels. The ASTM fire resistance standards for organic felt shingles require this type of shingle to meet a minimum of "Class C". The ASTM standards for fiberglass shingles require these to meet a minimum of "Class A" according to the E 108 "Test Methods for Fire Tests of Roof Coverings".

Asbestos-Containing Materials (ACM)

The majority of tests conducted on asphalt shingles have found no asbestos-containing materials (ACM). Testing performed by Ecology in 2007 (as described above) as well as laboratory tests conducted on the three RAS samples submitted for this project in August 2008 found no ACM.

Local health departments oversee RAS processing by solid waste handling permit and they allow processing of RAS, providing health and environment are protected. The *LinkUp* project team has put in place the best asbestos management scheme possible for the demonstration project by developing the RAS Specifications in consultation with our Advisory Group and Stakeholders; affected regulatory agencies including Labor & Industries, Puget Sound Clean Air Agency, Washington State Department of Ecology, King County Department of Public Health and other local county health departments in the region; shingles recycling processors; and roofing contractors. The *LinkUp* team has asked the relevant regulatory agencies to formally approve the RAS Specification as adequately addressing all environmental, health and worker safety regulations. The Tacoma-Pierce County Health Department and the Snohomish Health District have already provided formal acceptance of our RAS Specification.

Our asbestos management approach is both a "methods based" and "performance based" scheme for verifying the finished RAS product is free of asbestos containing material (ACM). The current version of the draft RAS spec states under "Section 1 - Overview":

> "…..the specification requires that the Operator, under contract to supply the RAS, and its Facility: …."
>
> - "….Perform testing on the finished RAS product and provide verification to certify that the RAS product does not include asbestos containing material (ACM) as per local, state and federal regulations; …."

And in Section 2.1:

> "Only asphalt shingles are admissible for the project. Other asphalt roofing products (e.g., built up roofing, rolled or sheet roofing, etc.) are not eligible."

And in Section 2.3:

> "Each incoming load of tear-off shingles for the demonstration project must be inspected by an Asbestos Hazard Emergency Response Act (AHERA) accredited inspector at the time of unloading at the Operator's Facility.

And in Section 2.4:

> "The finished RAS product must be randomly sampled and tested to ensure that it is free of ACM according to procedures specified in Section C. RAS Sampling and Testing Requirements."

And in Section 4 **-** "RAS Sampling and Testing Requirements

> "The Shingle Recycling Operator shall collect and test samples of the finished RAS product. The Operator shall document sampling methods and maintain adequate records of all testing results. ….."

IN CLOSING

Thank you very much for the opportunity to respond to your technical questions regarding the Shingles in Paving Demonstration Project. We hope we have adequately addressed your concerns. As you know, the extended project team has conducted extensive research to prepare and plan for this project and a key part of this preparation is putting in place strategies and tactics to mitigate the risk of premature pavement failure due to the addition of RAS in the HMA. These plans directly reflect the advice and direction from KCDOT and WSDOT as well as representatives of the project Advisory Group. We are fortunate to have such a diverse and capable group of organizations supporting this effort. To continue to ensure that our project mitigates risk to KCDOT, the *LinkUp* team recommends that KCDOT be involved closely in the project in the following ways:

- Review and formally comment on the following project draft documents:
    - Draft RAS spec
    - Test matrix
    - Request for Proposals to procure the services of the RAS supplier/processor
    - Draft HMA spec, including mix design (not yet released by WSDOT)
- Participate in upcoming facility site visits/interviews of candidate shingle recyclers that are eligible to become the County's contract RAS supplier/processor.
- Potentially organize a meeting to further discuss any outstanding priority questions. Additional meeting participants should include representatives from WSDOT. Other states' DOTs may also be invited, if necessary.

Endnotes

(a) Mn/DOT “Phase One” shingles recycling research projects leading to the adoption of their original specification in 1996:

- Turgeon, Curtis M. (February, 1991) "Waste Tire & Shingle Scrap Bituminous Paving Test Sections On The Munger Recreational Trail Gateway Segment." Office of Materials and Research, Minnesota Department of Transportation.

- Turgeon, Curtis M. (1993 circa**)** “Mn/DOT Physical Research Construction Report, T.H. 25 Shingle Scrap Project (S.P. 1006-20).” Minnesota Department of Transportation, [Constructed on June 17-21, 1991.] .

- Newcomb, David; Mary Stroup-Gardiner; Brian M. Weikle; and Andrew Drescher. (June 1993) "Influence of Roofing Shingles on Asphalt Concrete Mixture Properties." Report MN/RC-93/09, University of Minnesota, Minnesota.

  Summary and abstract at the link on the Minnesota Office of Environmental Assistance (OEA) *Environmentally Preferable Purchasing* web page:

  http://www.pca.state.mn.us/oea/market/resources/newcomb-summary.pdf

  Full report at the Mn/DOT web page (108 pages, 9Mb): http://www.mrr.dot.state.mn.us/research/MnROAD_Project/MnRoadOnlineReports/93-09.pdf

- Newcomb, David E.; Mary Stroup-Gardiner; Brian M. Weikle; and Andrew Drescher. (1993) "Properties of Dense-graded and Stone-mastic Asphalt Mixtures Containing Roofing Shingles." ASTM Special Publication 1193, ASTM.

- Janisch, David W. and Curtis M. Turgeon. (October 1996) “Minnesota's Experience Using Shingle Scrap in Bituminous Pavements (Final Report #96-34). Minnesota Department of Transportation, Maplewood, MN. Report No. PB-97-132278/XAB MN/PR--96/34.

  Link to Mn/DOT web page for PDF file: http://mnroad.dot.state.mn.us/research/MnROAD_Project/MnRoadOnlineReports/96-34.pdf

(b) Gallagher, Kevin P.; Hussain U. Bahia; Jason D. Guerra; and Jay Keating (January 1996) “The Influence of Air-blowing on the Performance Related Properties of Paving Asphalt” as presented at the Transportation Research Board 75th Annual Meeting January 7 – 11, 1996.

(c) Newcomb, David, et. al.(June 1993) - - op. cit.

(d) Janisch, David, et. al. (October 1996) – op. cit.

Attachment 1:

List of State DOT's Allowing RAS in HMA

State	State DOT Specs	RAS Type
Only Manufacturer Scrap Allowed:		
IN	5% M scrap only	M
MA	5% M scrap	M
MD	5% M scrap only	
MN	5% M scrap only	M
NC	5% M scrap only	M
NJ	5% M scrap only	M
OH	Project Approval by DOT Engineer	M
PA	Provisional Spec P—c04031A	M
TX	M scrap only	M
VA	Special provision	M
Tear-off Scrap Allowed:		
AL	5% M scrap or 3% T scrap	M,T
GA	5% M or T scrap	M, T
MO	7% M or T scrap,	M, T
SC	3-8% T scrap	T
WI	Maximum binder replacement	M, T

Key to type of shingle scrap allowed:

M: Manufacturers' shingle scrap is allowed and recycled

T: Tear-off shingle scrap is allowed

Attachment 2:

MoDOT Materials Specification 403:

Allowing RAS in HMA (Relevant Excepts)

(Source: MoDOT web page accessed 12-10-2008:
http://www.modot.mo.gov/business/standards_and_specs/sec0403.pdf)

SECTION 403

ASPHALTIC CONCRETE PAVEMENT

403.1 Description. This work shall consist of providing a bituminous mixture to be placed in one or more courses on a prepared base or underlying course as shown on the plans or as directed by the engineer. The contractor shall be responsible for QC of the bituminous mixture, including the design, and control of the quality of the material incorporated into the project. The engineer will be responsible for QA, including testing, to assure the quality of the material incorporated into the project.

…….

Recycled Asphalt Specifications
(Relevant Excerpts)

403.2.6 Recycled Asphalt. The asphalt binder content of recycled asphalt materials shall be determined in accordance with AASHTO T 164, ASTM D 2172 or other approved method of solvent extraction. A correction factor for use during production may be determined for binder ignition by burning a sample in accordance with AASHTO T 308 and subtracting from the binder content determined by extraction. The aggregate specific gravity shall be determined by performing AASHTO T 209 in accordance with Sec 403.19.3.1.2 and calculating the Gse to use in lieu of Gsb as follows:

$$G_{se} = \frac{100 - P_b}{\frac{100}{G_{mm}} - \frac{P_b}{G_b}}$$

403.2.6.1 Recycled Asphalt Pavement. Recycled Asphalt Pavement (RAP) may be used in any mixture, except SMA mixtures. A maximum of 20 percent may be used in mixtures without changing the grade of binder. Mixtures may be used with more than 20 percent RAP provided testing according to AASHTO M 323 is included with the job mix formula that ensures the combined binder meets the grade specified in the contract. All RAP material, except as noted

below, shall be tested in accordance with AASHTO TP 58, *Method of Resistance of Coarse Aggregate Degradation by Abrsion in the Micro-Deval Apparatus.* Aggregate shall have the asphalt coating removed either by extraction or binder ignition. The material shall be tested in the Micro-Deval apparatus at a frequency of once per 1500 tons (Mg). The percent loss shall not exceed the Micro-Deval loss of the combined virgin material by more than five percent. Micro-Deval testing will be waived for RAP material obtained from MoDOT roadways. All RAP material shall be in accordance with Sec 1002 for deleterious and other foreign material.

403.2.6.2 Recycled Asphalt Shingles. Recycled Asphalt Shingles (RAS) may be used in any mixture specified to use PG 64-22 in accordance with AASHTO PP 53 except as follows: A maximum of 7 percent RAS may be used. When the ratio of virgin binder to total binder in the mixture is less than 70 percent, the grade of the virgin binder shall be PG 52-28 or PG 58-28. Shingles shall be ground to ½-inch minus. Waste, manufacturer or new, shingles shall be essential free of deleterious materials. Post-consumer RAS shall not contain more than 1.5 percent wood by weight or more than 3.0 percent total deleterious by weight. Post-consumer RAS shall be certified to contain less than the maximum allowable amount of asbestos as defined by national or local standards. The gradation of the aggregate may be determined by solvent extraction of the binder or using the following as a standard gradation:

Shingle Aggregate Gradation	
Sieve Size	**Percent Passing by Weight**
3/8 in. (9.5 mm)	100
No. 4 (4.75 mm)	95
No. 8 (2.36 mm)	85
No. 16 (1.18 mm)	70
No. 30 (600 μm)	50
No. 50 (300 μm)	45
No. 100 (150 μm)	35

Attachment 3:

WisDOT Recycled Asphaltic Materials Specification

Allowing the Use of RAS in HMA

(Relevant Excerpts)

Source: WisDOT Web page as accessed on 12-10-2008:
http://roadwaystandards.dot.wi.gov/hcci/bid-letting/related-info/asp-6.pdf

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Effective with January 2009 Letting **ASP-6**

ADDITIONAL SPECIAL PROVISION (ASP) 6

MODIFICATIONS TO THE STANDARD SPECIFICATIONS

450.2.1 Acronyms and Definitions

Replace the entire text with the following:

(1) Interpret materials related acronyms used in sections 450 through 499 as follows:

FRAP Fractioned reclaimed asphaltic pavement

HMA Hot mix asphalt

JMF Job mix formula

PG Performance grade

RAP Reclaimed asphaltic pavement

RAS Recycled asphalt shingles

SMA Stone matrix asphalt

VMA Voids in mineral aggregate

(2) Interpret materials related definitions used in sections 450 through 499 as follows:

Asphaltic binder - The principal asphaltic binding agent in HMA. including asphalt cement and material added to modify the original asphalt cement properties.

Filler - A finely divided mineral aggregate added to asphaltic mixtures to improve mixture properties.

Fractioned reclaimed asphaltic pavement - Material resulting from cold milling or crushing existing asphaltic pavement processed to control gradation properties.

Leveling layer - Initial layer placed thinner than the minimum required under 460.3.2.

Lower layer - Any asphaltic pavement layer that will not be exposed to traffic when the pavement structure is complete. A pavement structure may have multiple lower layers.

Reclaimed asphaltic pavement - Material resulting from cold milling or crushing existing asphaltic pavement.

Recycled asphalt shingles - Waste material from a shingle manufacturing facility, either new or used material salvaged from residential roofing operations, or any combination of these materials ground to ensure that 100 percent will pass a 1/2 sieve and processed to remove deleterious material.

Upper layer - The asphaltic pavement layer exposed to traffic when the pavement structure is complete. A pavement structure has only one upper layer.

460.2.5 Reclaimed Asphaltic Pavement Materials

Replace the title and entire text with the following:

460.2.5 Recycled Asphaltic Materials

(1) The contractor may use recycled asphaltic materials from FRAP, RAP, and RAS in HMA mixtures. Stockpile recycled materials separately from virgin materials and list each as individual JMF components.

(2) Control recycled materials used in HMA by evaluating the percent binder replacement, the ratio of recovered binder to the total binder. Conform to the following:

MAXIMUM ALLOWABLE PERCENT BINDER REPLACEMENT

RECYCLED ASPHALTIC MATERIAL	LOWER LAYERS	UPPER LAYER
RAS only	20	15
RAP only	35	20
FRAP only	35	25
RAS and RAP	30	20
RAS and FRAP	30	25
RAS, RAP, and FRAP	30	25

(3) Ensure that the combined recycled and virgin aggregate conforms to the requirements of table 460-2 and to the gradation requirements of table 460-1.

460.2.6 Recovered Asphaltic Binders

Replace the entire text with the following:

(1) Establish the percent of recovered asphaltic binder from FRAP, RAP, and RAS for the mixture design according to AASHTO T 164 using the appropriate dust correction procedure. If production test results indicate a change in the percent of recovered asphaltic binder, the contractor or the engineer may request a change in the design recovered asphaltic binder. Provide at least 2 recent extractions from the contractor's mixture design laboratory supporting that change.

(2) The contractor may replace virgin binder with recovered binder up to the maximum percentage allowed under 460.2.5 without changing the asphaltic binder grade. If using more than the maximum allowed under 460.2.5, furnish test results indicating that the resultant binder meets the grade the contract originally specified.

Attachment 4:

Mn/DOT Specification Allowing the Use of Manufacturers' RAS in HMA

Minnesota Department of Transportation (Mn/DOT)
Standard Construction Materials Specifications,
Excerpt from

(2360) PLANT MIXED ASPHALT PAVEMENT
Combined 2360/2350 (Gyratory/Marshall Design) Specification

Mn/DOT's shingle scrap specification is found within
section 2360.2 Materials: A2h Scrap Asphalt Shingles.

Source: Mn/DOT web page as accessed on 12-11-2008:
http://www.dot.state.mn.us/pre-letting/spec/2005/2021-2360.pdf

Mn/DOT's shingle scrap specification (see section 2360.2 Materials: A2h Scrap Asphalt Shingles) was originally issued in 1995. The principal section of the Mn/DOT shingle scrap specification currently reads:

2360.2 Materials

"**A2h Scrap Asphalt Shingles** - Scrap asphalt shingles may be included in both wear and non-wear courses to a maximum of 5 percent of the total weight of mixture. Only scrap asphalt shingles from manufacturing waste are suitable. The percentage of scrap shingles used will be considered part of the maximum allowable RAP percentage (see Table 2360.3-B2a). Refer to Section 2360.2 G1 to select a virgin asphalt binder grade (use requirements for > 20% RAP, regardless of total RAP/shingle percentage). Scrap Shingle Specifications are on file in the Bituminous Office."

The following proposed specification amendment was recently presented by Mn/DOT's Bituminous Engineer (November 24, 2008):

(3) When shingles are included as part of the allowable RAP percentage in Traffic Level 2, 3, 4, or 5 mixtures the ratio of added new asphalt binder to total asphalt binder shall be 70% or greater ((added binder/total binder) x 100 >= 70). A minimum of 1 spotcheck per day per mixture blend is required to determine new added binder.

(4) When shingles are included as part of the allowable RAP percentage in LV and MV mixtures the added new asphalt shall be 3.5% or greater. A minimum of 1 spotcheck per day per mixture blend is required to determine new added binder.

APPENDIX C. RESOURCES

This appendix presents a list of resources with information on asphalt shingle recycling.

Appendix C. Resources

King County's *LinkUp* program has maintained a Web site of information about its market development efforts, including the Shingles in Paving Project and the paving demonstration. This Web site also includes a specific page of additional resources. For more information, see "Asphalt Shingles" at www.kingcounty.gov/linkup.

The following is a list of selected, resources intended to provide additional information about asphalt shingle recycling for educational purposes only.[1]

Organizations, Web Sites and On-Line Publications:

- The **Construction Materials Recycling Association (CMRA)** ***ShingleRecycling.org*** -Web site provides information on asphalt shingle recycling activities and is the base for announcements about upcoming events such as the series of asphalt shingles recycling forums. *ShingleRecycling.org* is also the organizational home for posting of the following CMRA publications:
    - *Recycling Tear-Off Asphalt Shingles: Best Practices Guide* (Oct. 2007).
    - Environmental Issues Associated with Asphalt Shingle Recycling authored by Timothy Townsend, Jon Powell and Chad Xu (Oct. 2007).
- ***Construction & Demolition Recycling*** magazine lists a variety of past *C&D Recycling* articles on its Web page when searched by the key words "Asphalt Shingles". For more information and articles, link directly to: http://www.cdrecycler.com/categories/detail.asp?SubCatID=86&CatID=7
- **National Asphalt Paving Association** (NAPA) supports an active research program designed to answer questions about environmental issues and to improve the quality of HMA pavements and paving techniques used in the construction of roads, streets, highways, parking lots, airports, and environmental and recreational facilities. NAPA provides technical, educational, and marketing materials and information to its members, and supplies technical information to users and specifiers of paving materials. For more information, link directly to: http://www.hotmix.org/index.php?option=com_content&task=view&id=130&Itemid=195. NAPA has recently published an updated version of the following helpful document:
    - *Guidelines for the Use of Reclaimed Asphalt Shingles in Asphalt Pavements* (November 2009). To order this guide, go to the NAPA Bookstore link directly to: http://store.hotmix.org/index.php?productID=702.
- **The Recycled Materials Resource Center (RMRC)** is a research center funded in part by the Federal Highway Administration (FHWA) and housed within the University of New Hampshire (UNH) at Durham, NH. RMRC conducts research and educational outreach leading to the

[1] The contents of these external resources do not necessarily reflect the views or policies of King County. The mention of trade names, individual companies, commercial products, or inclusion of Web links to sites describing such materials or services is provided for information exchange and educational purposes only. Such mention does not constitute an endorsement, recommendation for use, or any form of implied warranty.

development of appropriate guidelines for environmentally acceptable increased use of recycled materials in transportation applications. RMRC has published two documents on recycled asphalt shingles:

  - *Roofing Shingle Scrap - User Guidelines for Byproducts and Secondary Use Materials in Pavement Construction* (July 2008) a fact sheet. To view this fact sheet, link to directly to: http://www.rmrc.unh.edu/tools/uguidelines/rss1.asp
  - *Overcoming the Barriers to Asphalt Shingle Recycling: Final Report for the Recycled Materials Resource Center Project 22* (Feb. 2005). To view or download this report, link through: http://your.kingcounty.gov/solidwaste/linkup/documents/Overcoming_barriers-shingle.pdf.

- **The Roofing Contractors Association of Washington (RCAW)** works to improve the roofing industry in the state of Washington for residential and commercial contractors, manufacturers, distributors, and industry professionals. For more information, link directly to: http://www.rcaw.com/.
- **Roofs to Roads Colorado** is a non-profit organization promoting, organizing and coordinating shingle recycling activities in Colorado. For more information about Roofs to Roads Colorado, link directly to: http://roofs2roadscolorado.org/aboutus.php. Together with the Colorado Asphalt Pavement Association (CAPA), Roofs to Roads Colorado co-sponsored a webinar on November 12, 2009 on recycled asphalt shingles:
  - From CAPA's Technical Resources Library: *Recycled Asphalt Shingles (RAS).* For webinar presentations, link directly to: http://www.co-asphalt.com/documents/Resources_Files/RAS.doc.
- **University of Washington** (UW) maintains a ***Greenroads*** Web site dedicated to pavement environmental rating system that distinguishes high-performance sustainable new, reconstructed or rehabilitated roads. The *Greenroads* system awards credits for approved sustainable or environmentally friendly choices/practices and can be used to certify projects based on total point value. This site is administered as a part of a larger Web site project known as *Pavement Interactive.* For more information, link directly to: http://pavementinteractive.org/index.php?title=UW:Green_Roads.
- **Washington Asphalt and Pavement Association (WAPA)** is an asphalt paving industry association that represents nearly all hot mix asphalt producers in Washington State and serves as a source for information on the asphalt industry in Washington State and across the country. WAPA provides communication, research, education, and innovative design and specifications. For more information, link directly on: http://www.asphaltwa.com/.

State & Federal Standards

- The Association of American State Highway and Transportation Officials (AASHTO) amended its shingle recycling specifications in 2008 as published in July 2009:
  - AASHTO MP015-09-UL: Standard Specification for Use of Reclaimed Asphalt Shingles as an Additive in Hot Mix Asphalt (HMA). *(For ordering information, link to: https://bookstore.transportation.org/item_details.aspx?ID=1420.)*

- AASHTO PP053-09-UL: Standard Practice for Design Considerations When Using Reclaimed Asphalt Shingles (RAS) in New Hot Mix Asphalt (HMA). *(For ordering information, link to: https://bookstore.transportation.org/item_details.aspx?ID=1421.)*

APPENDIX D. STAKEHOLDER AND ADVISORY GROUP DOCUMENTS

This appendix includes the following documents.

- Meeting minutes from the August 21, 2007 stakeholder meeting.
- Meeting minutes from the following advisory group meetings:
  - October 16, 2007
  - July 8, 2008
  - November 4, 2008
  - December 3, 2009
- Advisory Group Charter, October, 2007

King County Shingles in Paving Demo Project
Stakeholder Meeting Notes

Tuesday, August 21, 2007

Key Outcomes:

- The meeting included a relatively large turnout (about 40 people participated, including presenters) with representatives from most key stakeholder/interest groups.
- Stakeholders agree there are no compelling reasons not to pursue the project, assuming tight quality assurance/quality control (QA/QC) practices and procedures are implemented.
- Stakeholders requested summary of related projects and test results, as well as specifications.
- There is a need for a tight recycled asphalt shingles (RAS) specification, both for purposes of any engineered use in hot mix asphalt (HMA) and for environmental/health protection.

Objective and Overview of Asphalt Shingles Demonstration Project
Presenter: Kris Beatty, LinkUp Program Manager, King County Solid Waste Division

Objective:

- Champion development of market for tear-off shingles
  - Currently, 17,000 tons of asphalt shingle waste a year in King County (outside Seattle); 16,000 tons sent to landfill
  - Material is currently not used in hot mix asphalt in Washington state
- Verify project strategy for use in hot mix asphalt is the highest priority use of material
- Use trials done by other states as examples

Overview:

- Phase I: Involve other public agencies to gather input and develop a plan
- Phase II: Contact asphalt producers and gauge their ability and willingness to provide material; form partnerships
- Phase III: Develop user specifications
- Phase IV: Monitor production, perform tests, produce and publish reports

Questions:

- Product testing - will there be monitoring for long-term performance?
- Opportunity to perform accelerated tests in the lab - is this a good option?
- How can we accurately test performance? This is one of the biggest challenges in the hot mix asphalt industry.

Current Status of Tear-off Shingle Recycling: Other State Efforts
Presenter: Dan Krivit, Dan Krivit and Associates

Dan Krivit's key points (PowerPoint presentation is attached):

1. Recycling of tear-off RAS in HMA is feasible if strict QA/QC procedures are followed.
2. Other applications for the use of RAS can be explored and monitored. But recycling into HMA is the most well researched and has the greatest, immediate potential demand, and therefore should be highest priority for the LinkUp project.

3. There are multiple facilities nationwide that successfully recycle tear-off shingles into HMA.
4. There are several states that regulate these facilities and RAS recycling.
5. The King County *LinkUp Shingles in Paving Demo Project* can learn from these case studies to develop its own unique demonstration design.
6. Shingle recyclers should plan to meet or exceed minimum requirements for both RAS material quality and environmental regulations.
7. There are a variety of benefits for recycling RAS into HMA (e.g., helps prevent rutting, reduces landfilling, and reduces need for virgin asphalt cement). There are also engineering challenges that must be managed (e.g., the asbestos issue, nails, and impacts on final HMA asphalt binder).
8. The economics of recycling shingles are determined by local conditions including the prevailing prices of disposal at landfills, the prices for virgin asphalt cement, the quality of the final RAS product to be used in HMA, and the costs of sourcing, processing, and recycling.
9. Much of the information about past case studies is already posted on www.ShingleRecycling.org.
10. There is an excellent opportunity for *LinkUp Project Stakeholders* to learn much more detailed information about tear-off shingle recycling at the upcoming *"3rd Asphalt Shingle Recycling Forum"* to be held in Chicago on November 1 – 2, 2007. (Link to the *Forum* web page at www.ShingleRecycling.org for more information and to register.)

Questions:

- What percentage of tear-off shingles can be used in HMA?
  Current specifications allow "up to five (5) percent" of shingle scrap to be used in HMA. Tear-off shingles are generally richer in asphalt cement and may be more unpredictable than manufacturers' shingle scrap when used in HMA. Missouri DOT has allowed two (2) percent tear-off RAS without adjusting the virgin asphalt binder grade.
- Is there an existing specification that details how much adjustment to make to the virgin binder?
  No one specification with a blanket percentage applies to all mixes. The Missouri specification and the AASHTO specification come closest to providing the necessary guidance. Need to consider all factors that affect the mix design and final HMA product including (but not limited to):
  - *Specified pavement application (e.g., type of road);*
  - *Performance grade (PG) of virgin asphalt cement (AC) binder;*
  - *Amount and AC binder PG grade in the RAS;*
  - *Gradation and amount of the RAS;*
  - *Amount and AC binder grade of recycled asphalt pavement (RAP);*
  - *HMA plant temperature and retention time;*
  - *Moisture content of RAS and RAP; and*
  - *Age of material.*

  To maximize amount of tear-off shingles in a mix, consider adjusting the virgin binder. This may raise the cost but help mitigate the potential for increased low temperature cracking.
- Have there been any long term studies?
  Some roads with shingles in the HMA have been in use since 1990 or earlier. While controlled surveys and published research that document the performance of these roads have not yet been completed, they are still in use and performing as designed.

Project approach
Presenters: Julie Colehour, Colehour+Cohen and Katie Kennedy, Cascadia Consulting Group
Lead Discussion with Dan Krivit, DKA as Technical Expert

Key Points:

- Regulatory agencies stated that they would not have a problem with a demonstration project plan if the supply of tear-off shingles is controlled to prohibit asbestos containing material (ACM).
- The asphalt cement (AC) content in shingles is valuable as a paving additive and therefore shingles should be a candidate for landfill diversion.
- HMA manufacturers cited cost-savings as a primary reason for using tear-off shingles in their mix. They also strive to be environmentally conscious.
- City of Seattle representative stated there may be an exception to 90/10 hauling rule for shingle recycling loads, allowing them to be hauled by other companies that certificated haulers, depending on the details of the proposed demonstration project, including sources and composition of the loads.
- Specific dust control measures may be necessary to proactively protect worker health and safety.
- WSDOT representatives stated they do not want to use the standard asphalt cement (AC) "wash out" lab method that utilizes chlorinated solvents for measuring AC content in material samples (e.g., HMA, RAP or RAS) due to the toxicity of such solvents.
- Agency departments of transportation (DOT) representatives are hesitant to use tear-off asphalt shingles in the absence of successful trials.
- Ideally, more than one trial should be conducted. Replication at multiple pavement construction sites would be beneficial in determining performance.
- Spring is the optimal time for paving contractors and their HMA suppliers.
- Using shingles in the HMA base course layer only can be one means to reduce risks of any negative pavement impacts.
- Long-term performance analyses may require 5 to 15 years of monitoring.
- The demonstration project should call for at least 1,000 tons of HMA to allow the HMA operator a better chance to optimize the plant to accommodate the addition of tear-off RAS and to assure the best final HMA product possible.
- The demonstration should be able to be accomplished between one and two years.
- An extended bid time should be provided to allow the HMA manufacturer(s) and RAS supplier(s) to adequately consider plant changes and estimate costs for the use of tear-off shingles in the mix.
- There was a suggestion that the *LinkUp Project* team should also consider using tear-off shingles as road base aggregate.
- Private, commercial options should be considered for the demonstration paving project, such as parking lots, etc.

Next Steps
Presenter: Julie Colehour, Colehour+Cohen

- Distribute information packet to attendees (to include previous projects' test results and other existing specifications)
- Identify one or more engineer(s) to attend upcoming *3rd Asphalt Shingle Recycling Forum in Chicago* (November 1- 2, 2007); King County could potentially assist with the costs for someone to attend if there is interest

- Form advisory group
- *Project* team and advisory group to further discuss:
  - Type of project
  - Technical requirements
  - Testing requirements
  - Alternative uses, such as aggregate road base
- Determine if *Project* should move forward

These notes summarize the first meeting of the Advisory Group for the King County LinkUp Shingles in Paving Demonstration Project. The meeting was held on Tuesday October 16, 2007 at the King Street Center in Seattle, WA.

The following Advisory Group members participated:

- *Bill Brickey, Wilder Construction Company*
- *Joe DeVol, WSDOT*
- *John Grisham, Woodworth & Company*
- *Kevin Kelsey, KCDOT*
- *Dick Lilly, SPU*
- *Merv Reykdal, ARR*
- *Jim Weston, WSDOT*
- *Victor Woo, KCDOT*

The following project staff participated:

- *Kris Beatty, King County LinkUp*
- *Julie Colehour, King County LinkUp Consultant Support (Colehour + Cohen)*
- *Michelle Caulfield, King County LinkUp Consultant Support (Cascadia Consulting Group)*
- *Dan Krivit, King County LinkUp Consultant Support (Dan Krivit & Associates)*

The following Advisory Group members were absent but were given the opportunity to provide input and feedback on the draft meeting notes:

- *Jim Eagan, KCDOT*
- *Ben Hansen, SDOT*
- *Rick Hess, Puget Sound Clean Air Agency*
- *Steven Read, SPU*
- *Gabriella Uhlar-Heffner, SPU (Dick Lilly participated on Gabriella's behalf)*
- *Jeff Uhlmeyer, WSDOT (Jim Weston participated in Jeff's behalf)*

MEETING OBJECTIVES

- Approve the charge and charter of the group
- Address any outstanding questions from a memo recently sent to project stakeholders to summarize research on the use of asphalt shingles in hot mix asphalt.
- Review the refined scope of work for project
- Discuss and develop criteria for selecting a paving demonstration project

KEY OUTCOMES

- The group approved the draft advisory group charter
- There was a good discussion about the research memo. Overall, the group seemed to find the research helpful in thinking about needs specific to a King County project.
- The group felt the refined scope of work was thorough and complete.
- There was fairly good agreement on the "musts" and "wants" in terms of the selecting the best demonstration project in King County.

- There was a general feeling that this is the right group to lead a successful demonstration project in King County.

AGENDA ITEM #1: OVERVIEW OF ADVISORY GROUP

Kris Beatty presented the charge and charter for the group, which included a brief summary of the problem, the role of King County and Advisory Group members, and the scope of the group.

- *The group approved draft advisory group charter.*

AGENDA ITEM #2: RESEARCH SUMMARY MEMO

As a follow-up to the August 21 stakeholder meeting, the project team drafted and circulated a memo to summarize research on the use of asphalt shingles in hot mix asphalt. The lessons learned and opportunities in the current body of research are the foundation for the King County demo project. Overall, the group found this research summary useful and relevant. Below is a summary of the discussion surrounding the research memo.

What is the difference between manufacturing scrap and tear-off scrap (Jim Weston)?

- Manufacturing scrap is generally free of nails and other debris, newer, from a single source, more easily certified, more researched so the properties are more well-defined, is about 1/10th of the volume of tear-off scrap, and is not always being landfilled (Dan Krivit).
- Tear-off scrap can be from a diverse set of sources. It is a post-consumer material so more likely to be contaminated. Asbestos is more of a concern. Tear-off scrap and tear-off can be higher in asphalt content (Dan Krivit).

What is the maximum size for the recycled shingle (Victor Woo)?

- Typically 1/2 minus but some want it finer (7/16) to get more utilization and quality-control (Dan Krivit).

In terms of the retained tensile strength test, is this the Lottman Test (Victor Woo)?

- I think so, but I would need to get back to you (Dan Krivit).
- It seems the question is really about moisture and susceptibility, which would be the Lottman test. This would be tested for during design (Joe DeVol).

Are we talking about only tear-off shingles (Joe DeVol)?

- Yes (Group)
- There are sources of manufacturing scrap. Pabco Roofing in the Port of Tacoma is making 3-tab (asphalt shingles). Thinks the scrap is currently going to landfill in Aberdeen (John Grisham). Also there is IKO in Sumas. Believe IKO is sending their scrap north of the border for use as fuel for a cement plant and in HMA (Bill Brickey).

Comments and clarifications on the memo (Joe DeVol):

- Page 5 of the memo: clarification that the last bullet refers to the percentage of the RAS as feedstock, not the final mix.

- Page 5 of the memo: first bullet should be decreased, not increased.
- Good catches, we will update the memo (Dan Krivit and Kris Beatty).

Can you tell me more about the forthcoming publications on the Ramsey County, MN project highlighted in the memo (Joe DeVol)?

- There are presentations online and there will be written summaries developed for the grant but they are not peer reviewed. Dan will provide these written observations to the group when that is complete. There is talk about the value in a journal publication, but no firm plans to do so currently. Several of the key researchers on this work will be at the shingles conference in Chicago, so that might be a good time to connect with them further (Dan Krivit).
- It would be good to see more recent results from the MNDOT project (Joe DeVol).

Who is attending the Shingle Forum in Chicago in November 1 & 2 (Dan Krivit)?

- Kris Beatty (King County LinkUp)
- John Grisham and maybe Butch Brooks, VP (Woodworth & Company Inc)
- Bill Brickley or other representative (Wilder Construction Company)
- Merv Reykdal and Barbara Williams (American Roofing Recyclers)
- Jim Eagan (KCDOT)
- Joe DeVol (WSDOT)

I am interested in knowing more about the RMRC (Recycled Material Resource Center) recommendations of AASHTO procedures (Joe DeVol).

- Two organizations have separate recommendations forthcoming. One from a task force that includes Missouri, Kentucky and Minnesota as part of the Spring 08 AASHTO ballot. Second is a best practices guide being developed by CMRA (Construction Materials Recycling Association). This is a white paper on environmental issues that will be posted after the Shingle Forum (Dan Krivit).
- Shinglesrecycling.org is the one-stop shop for the reports and studies on shingles recycling in paving projects (Dan Krivit).

AGENDA ITEM #3: REVIEW REFINED PROJECT STRATEGY (SCOPE OF WORK)

Michelle Caulfield walked the group through the refined project strategy (scope of work document). The strategy has been modified from the original scope of work based on input from agencies representatives and stakeholders. The group felt the strategy was thorough and on the right track. Following is a summary of questions or comments raised.

What is the plan for testing and evaluation? Will we specifically look at smoothness and rideability tests for example (Jim Weston)?

- We will be looking to this group for input on the right mix of testing and evaluation (Michelle Caulfield & Kris Beatty).

- We will look at the standard list of performance tests and then inquire with you all about additional that tests need to be done (Dan Krivit).
- We have a small budget for testing and lab work though we would like to explore if there is a lab that would donate services as well (Kris Beatty).

Will there be a control section (Jim Weston)?

- Yes (Dan Krivit).

AGENDA ITEM #4: DISCUSS PROJECT CRITERIA

Julie Colehour facilitated a discussion on the musts and wants for the ideal project to demonstrate and test tear-off shingles in a King County paving project. The full list of musts and wants are below, followed by a summary of the discussion.

Musts:

- Piggy-back within existing project
- Minimum quantity of 3,000 tons of HMA
- Allow project selected to drive specification
- Only variable should be RAS (3%-5%)
- Need control strip
- Use a common mix (75 gyrations)
- Overlay project (remove and replace)
- Top course to better show impacts
- Make sure project has good underlay
- Pre-site review needed to determine the project has a good underlay

Wants:

- High-load project (e.g. transfer station, industrial, bus route, port)
- King County project

Key Discussion Points

- We should consider the full range of projects for using tear-off shingles including parking lots, residential streets, etc. Roads are not the only use of the material and the goal is to get the stuff out of landfills. It will be the job of agencies from a policy perspective to help grow the market for this material through tools such as manipulating tipping fees. Did not see these market development activities on the scope of work document (Dick Lily).
- We will use the results of the demonstration to pursue market development (Kris Beatty).
- From a producer standpoint, we should try to demonstrate the highest level use – however, minimizing risk is key. Need the comfort level as a producer. Three key recommendations from the producer perspective 1) Don't try too much complexity right away – more risk equals more complexity; 2) Require that specs be met within reason; 3) Take baby steps (John Grisham)
- Recommendation from several in the group that we be clear about what is unique to our climate and environment (e.g. moisture issue) and don't spend time testing what has already been tested elsewhere. Don't reinvent the wheel (Several members).

- Woodworth has projects with tear-off shingles in private projects already. This is doable. This is the right group to get the specs that we need (John Grisham).
- Don't analyze for ten years, let's do this right, start small, low impact project and work up. Also consider a two-phase demonstration (Kevin Kelsey).
- Parking lots and trails are not appropriate. Start with a high load project. Adding RAS changes the oil properties, makes it stiffer. Appropriate for this kind of mixture. Add 5% shingles and go with a lower grade oil (Victor Woo).
- What County projects are up and coming? This drives the project and the specs (Joe DeVol). We need to select the project first; the project will drive the specification development (Several members).
- The demonstration will likely be a piggyback on a large project (Several members).
- We should be looking for a project that offers 2,500 to 3,000 tons of HMA to test.
- To be successful, the project needs to be relatively easy on the producer.
- Start with a high load project; parking lots and trails can come into play down the road (John Grisham).
- How much risk do we want to take on? WSDOT would not typically put it in a high load to get funding. Do we want more assurances before putting into a more high risk area? Eliminating risk will be an issue in the bidding process (Joe DeVol).
- The County has been using WSDOT mixes that are not as appropriate for the County. Maybe we should be looking at the County and the future types of mixes it intends to use (75 gyrations versus 100 gyrations). King County is looking to revise the standard it uses (Victor Woo).
- WSDOT is also set up to do – and does – 75 gyration mixes. 75 gyration is common ground between the County and the State (John Grisham).
- Is there a preference for overlay or base course (Kris Beatty)? There was general agreement on an overlay as this project will likely be funded as part of an overlay project. A key factor in the project will be to ensure that the base course is solid and sound. Site review should be part of the project selection process. We will want to assess the underlying subgrade with whatever project we select.
- Is there any room here for a low impact project (like a trail or sidewalk) where we can beef up the RAS percentage to 10% to 12% in order to get more shingles out of the landfill. Perhaps low impact projects could readily absorb the tear-off shingles out there (Merv Reykdal). Our research so far has shown that those types of projects don't have potential to divert as much materials as roadways (Julie Colehour). Typically the low impact (trails) demonstration projects across the country only use a 5% or less RAS (Michelle Caulfield). Yes. Most are still based on the same standard as road projects. Successful road projects can drive non-road projects. This helps to assure success and offers greater relevance. Relevance will flow downward (Dan Krivit).
- *One comment made subsequent to the meeting by Jim Weston to Kris Beatty was that if the selected project has a trail or sidewalk area adjacent to it and part of the project, then it may be easy to do a small section with the HMA containing RAS even at a higher percentage to see how it performs (Jim Weston).*

NEXT STEPS

- Attend Shingles Forum and report back.
- Kris Beatty to work on researching possible King County projects.
- Team to draft notes from meeting and distribute.

King County LinkUp Shingles in Paving Demo Project
Summary of Advisory Group Meeting #2, Tuesday July 8, 2008

These notes summarize the second meeting of the Advisory Group for the King County LinkUp Shingles in Paving Demonstration Project. The meeting was held on Tuesday July 8, 2008 at the King Street Center in Seattle, WA.

The following Advisory Group members participated:

- *Bill Brickey, Wilder Construction Company*
- *Joe DeVol, WSDOT*
- *Kevin Kelsey, KCDOT*
- *Merv Reykdal, American Roofing Recyclers*
- *Jim Eagan, KCDOT*
- *Steven Read, SPU*
- *John Yeasting, Glacier Recycle*
- *Gabriella Uhlar-Heffner, SPU*
- *Jeff Uhlmeyer, WSDOT*
- *Victor Woo, KCDOT*

The following project staff participated:

- *Kris Beatty, King County LinkUp*
- *Julie Colehour, King County LinkUp Consultant Support (Colehour + Cohen)*
- *Katie Kennedy, King County LinkUp Consultant Support (Cascadia Consulting Group)*
- *Dan Krivit, King County LinkUp Consultant Support (Dan Krivit & Associates) (via phone)*

The following Advisory Group members were absent but were given the opportunity to provide input and feedback on the draft meeting notes:

- *Ben Hansen, SDOT*
- *Dick Lilly, SPU*
- *John Grisham, Woodworth & Company*
- *Jim Weston, WSDOT*
- *Rick Hess, Puget Sound Clean Air Agency*

MEETING OBJECTIVES

- Provide project update
- Describe project selection process
- Review recycled asphalt shingles (RAS) specification
- Describe RAS procurement process
- Discuss pavement test section

KEY OUTCOMES

- The group discussed the pros and cons of the condition of the road project and how the demonstration and control sections should be paved.
- There was a good discussion about the draft RAS spec.

- There were differing opinions as to whether RAP should be included in the demonstration project. It was determined that the project team should regroup on this issue.
- There was fairly good agreement on the details of a test section.

AGENDA ITEM #1: PROJECT UPDATE

Kris Beatty recounted happenings since the last Advisory Group Meeting: several members attended the 3rd Asphalt Shingle Recycling Forum in November, Seattle Public Utilities committed $10,000 to supporting project, and KCDOT has committed to being a partner in the project. (Copies of the project budget and timeline were handed out.)

AGENDA ITEM #2: PROJECT SELECTION PROCESS

Kevin Kelsey outlined the project selection process in the following steps.

1) Preconstruction paving condition survey: walk the road and do detail of current state
2) Look at different patterns with cracks: note those areas for future reference
3) Core the roadway to look at consistency and look at conditions of cores
4) Consider performing some subsurface evaluation of soils in that area to determine soil conditions
5) Deflectometer testing: put pressure on asphalt to simulate truck load in order to predict light structural integrity of roadway
6) Fix cracks
7) Construction monitoring and documentation for gradation and testing
8) Findings summarized in a report
9) Post-construction monitoring will include paving condition monitoring on an annual basis

Below is a summary of the discussion surrounding the project selection process.

How much shingles will likely be needed (John Yeasting)?

- 3% to 5% of 3,000 tons will be shingles (Victor Woo).

There were several suggestions about the type of road and how it should be paved.

- The same paving mix will be used on the shoulder (Kevin Kelsey).
- It would be helpful to have a section of roadway that includes varied pavement as well as problem sections (Steven Read).
- Paving section should have a lot of loading (Steven Read).
- If it does vary, perhaps only pave one lane to see comparison (Gabriella Uhlar-Heffner).
- If you go 3 miles, you can still do test sections back to back (Jeff Uhlmeyer).
- We might do a combination of side-to-side and end-to-end (Jim Eagan).
- What's the planning ratio of experimental with non-experimental? 50/50? I think it depends on the road specifics (Dan Krivit).
- How much are we laying down per day (Kevin Kelsey)?
- 2,000 tons per day; 1,400 per day for residential (Jim Eagan).

- This will probably be a 2-day operation (Steven Read).
- Using a "Hopper" or shuttle buggy is standard procedure for SDOT and KCDOT would like to require it on this project (several).

Overall, what's the total tons of pavement laid down by King County (John Yeasting)?

- About 140,000 tons per year, between us and our partnering agencies, not including transit or other paving. (Jim Eagan)

Would this group be able to help with evaluation on a private project that used 25% shingles in the mix design (John Yeasting)?

- KCDOT has concerns about liability (Jim Eagan).
- KCSWD might be able to support such an effort (Kris Beatty).

AGENDA ITEM #3: RAS SPECIFICATION REVIEW

Dan Krivit mentioned several key goals of the RAS spec.

- Develop a 2-spec theme. This is the RAS spec and Joe is working on the HMA spec, but that's not a subject for today's meeting.
- Intent is to ensure engineering performance of HMA including specifics about gradation, deleterious limits, and moisture levels.
- Provide for worker safety/health.
- Provide a scheme to allow for KC to go through a procurement process for this demonstration. This is based on other specs and the proposed amendments to the AASHTO shingles spec.

How do we define "shall contain no known hazardous material" (Bill Brickey)?

Would like to see language changed to "is not known to contain hazardous material" rather than "no known hazardous material" (Bill Brickey).

What about fumes from heating it (Kris Beatty)?

- I'm not aware of any known data or risk from the hot mix plant itself. There are no known stack tests with and without shingles (Dan).

I have been questioned about the asbestos issue as well as fire retardants. How do we know shingles are safe to use (Kevin Kelsey)?

- I'm not sure about fire retardants. I think asbestos is the #1 environmental concern. We have a fairly aggressive plan to test shingles. If there are other questions, such as flame retardants or hot mix plant fumes, we should record those and re-visit (Dan Krivit).
- Grinding does increase the risk of dust exposure to workers operating the shingles recycling plant. The dust management plan overall needs to be addressed by operators and something King County should look at very carefully when reviewing qualifications (Dan Krivit).

Dan will look into what has been learned about chemicals that shingles contain from other demonstration projects.

Wondering about limitation to only non-regulated structures. Our experience is that larger structures have much more monitoring and testing. If a larger structure, but has had an AHERA survey, what's the downside (John Yeasting)?

- This is based on how other states, such as Minnesota, have addressed this issue. This demonstration project should not be viewed as precedent-setting (Dan Krivit).

Several members of the group suggested revisions to the RAS spec, which Dan Krivit will incorporate into the next version. A discussion on the merits of including RAP followed Dan Krivit's statement that the current plan is to not include RAP in the mix. Highlights are listed below.

- Would it be compared to a conventional virgin mix then (Kevin Kelsey)?
- Yes (Dan Krivit).
- Contractors will choose RAP over RAS. Will we need a new demonstration three years from now with RAP and RAS? If the intention is to make an acceptable product, then maybe include RAP (Kevin Kelsey).
- RAP is too variable. Because we want a good estimation of RAS, we should limit the variables. Maybe test for RAP in 2010 (Joe DeVol).
- This is the first step towards a spec that will include RAS and RAP (Dan Krivit).
- Although it may be preferable to limit the variables from a study standpoint, it is a dead issue if it can not be incorporated with RAP (Steven Read).

AGENDA ITEM #4: RAS PROCUREMENT PROCESS

It was decided that a description of the procurement process would be distributed via email due to insufficient time during the meeting.

AGENDA ITEM #5: REVIEW DRAFT TESTING PROTOCOL

Joe Devol described the testing that WSDOT will likely do on the mix design. We would test gradation, asphalt content, binders on RAS from suppliers on pre-approved list. With that information, we can recommend changes on mix design.

AGENDA ITEM #6: TEST SECTION DISCUSSION

Joe DeVol informed the group that the team is considering an off-site test section. The goal is to, first, minimize concerns or questions with the laboratory analysis. Then, place the mix somewhere it can be evaluated and work out constructability issues prior to placement on the roadway. Call it "off-site test section" or "calibration strip." On the project, because of short distance, you can't go through much testing.

How many tons off-site (Jim Eagan)?

- I think paving manufacturers will want 200 to 600 tons of HMA before they feel comfortable (Joe DeVol).
- I would tend more towards 600 tons. (Bill Brickey).
- It would be great if we could use ATB (Steven Read).

- We did a test section in front of our plant in Everett and that worked out pretty well. We're a gravel producer too; we could pave a strip out in one of our gravel yards (Bill Brickey).
- Only problem is additional charge per ton (Joe DeVol).
- It is a little bit of a cost penalty to not allow the use of RAP, to produce an all-virgin mix in terms of AC prices the way they are (Bill Brickey).

At our first advisory group meeting, we talked about a plant needing 3,000 tons of material. We would benefit from knowing how it would work for a plant to do that twice for test section and for the experiment. And, what would the timing be (Kris Beatty)?

- It is preferable to do it reasonably close (1-2 days) to the production paving to minimize changes in your aggregate. We would not want them to be separated by 2 months (Bill Brickey).
- Think the bigger issue is switching between mixes in a day. Plant production should be dedicated for a full day (Steven Read).
- I don't know if that's an issue at other plants, but we switch all the time and don't find an issue with that (Bill Brickey).
- One recommendation is to do test section 2 days before. I remember hearing as low as 2,000 tons (Joe DeVol).
- We've heard as low as 1,000 tons (Katie Kennedy).

NEXT STEPS

- Dan will share AASHTO spec with the group.
- Team to draft notes from meeting and distribute along with a description of the RAS procurement process.
- Convene again in September.

These notes summarize the third meeting of the Advisory Group for the King County LinkUp Shingles in Paving Demonstration Project. The meeting was held on Tuesday, November 4, 2008 at the King Street Center in Seattle, WA.

The following Advisory Group members participated:

- *John Grisham, Woodworth & Company, Inc.*
- *Bob Lee, Kevin Kelsey, Frank Overton, and Victor Woo, KCDOT*
- *Jim Weston and Joe DeVol, WSDOT*
- *John Yeasting, Glacier Recycle*
- *Dick Lilly and Gabriella Uhlar-Heffner, SPU*
- *Preston Horne-Brine, American Roofing Recyclers*
- *Ben Hansen and Steven Read, SDOT*
- *Rick Stewart, Stewart Roofing*
- *Bill Brickey, Wilder Construction Company*

The following project staff participated:

- *Kris Beatty, LinkUp, King County Solid Waste Division (KCSWD)*
- *Julie Colehour, King County LinkUp Consultant Support (Colehour+Cohen)*
- *Michelle Caulfield, Katie Kennedy, King County LinkUp Consultant Support (Cascadia Consulting Group)*
- *Dan Krivit, King County LinkUp Consultant Support (Dan Krivit & Associates) (via phone)*

The following Advisory Group members were absent but were given the opportunity to provide input and feedback on the draft meeting notes:

- *Jeff Uhlmeyer, WSDOT*
- *Jim Eagan, KCDOT*
- *Rick Hess, PSCAA*

MEETING OBJECTIVES

- Provide project update
- Provide road selection update
- Give summary of recycled asphalt shingles (RAS) procurement process
- Describe and discuss significant changes to RAS specification
- Provide updates on project design

KEY OUTCOMES

- There was a brief discussion about how the RAS should be procured (e.g, ITB, RFQ, RFP, donated). County Roads Services representatives explained the importance of using a standard procurement method, and that an invitation to bid (ITB) was the method they were likely to use.
- It will most likely work for shingles to be delivered directly from processor to paving contractor in one, bulk shipment.
- There were several concerns that the requirements in the latest draft RAS specification are too stringent (e.g., restricting supply of shingles to come from “single family, owner occupied” buildings only).

- There was preliminary consensus that the mix types should include 3% RAS and 15% RAP based on draft WSDOT test data from samples in response to the request for information (RFI).

AGENDA ITEM #1: INTRODUCTIONS AND AGENDA

Kris Beatty conveyed the unfortunate news of Merv Reykdal's passing on October 7th. You are welcome to add a note online in his memory at Legacy.com for his family and friends to read.

Kris welcomed several new members to the group, including Preston Horne-Brine, who will represent American Roofing Recyclers, Bob Lee and Frank Overton of KCDOT, and Rick Stewart of Stewart Roofing.

AGENDA ITEM #2: PROJECT UPDATE

Kris Beatty recounted happenings since the start of the project, including

- The advisory group was formed and met twice,
- WSDOT agreed to lead the HMA mix design,
- SPU joined as a funding partner,
- KCDOT committed to supply an overlay paving project, and
- Ecology recently awarded King County Solid Waste Division a $75,000 Community Planning Grant (CPG) to be used for the project for the next 2 years.

Julie summarized the upcoming schedule (*see Handout: Project timeline).* Several key milestones lie ahead including:

- Completing the HMA mix design,
- Finalizing the procurement process for RAS supply, and
- KCDOT advertising the invitation to bid (ITB) and selecting a contractor for the pavement construction project.

AGENDA ITEM #3: ROAD SELECTION PROCESS

Kevin Kelsey reported that KCDOT has narrowed the list of potential projects down to five roads, mostly in South King County, using the list of criteria recently distributed to the advisory group members. They will likely select the road in January, and then go on to do preliminary testing and document any repairs done to the roadway prior to paving.

AGENDA ITEM #4: RAS PROCUREMENT PROCESS

Kris explained that there were three respondents (American Roofing Recyclers, Woodworth, and Glacier Recycling) to the project request for information (RFI). Joe DeVol has conducted preliminary testing on the samples gathered from the respondents. Rather than issuing a request for qualifications (RFQ), KCDOT plans to purchase the product directly through an ITB.

How would paving contractors want the RAS delivered (Frank Overton)?

- It should not be a problem to receive a bulk load of shingles and find space to store them on site (John Grisham and Bill Brickey).

- It may be a problem for Watson (Victor Woo).

There was a discussion over how best to procure the RAS that included the following suggestions:

- Potential procurement methods include ITB or RFP
- Roll purchase into a construction contract, such as the small-works construction contract
- The processors may be willing to provide this amount of material free of cost

There was a consensus to use the ITB approach such that the County would purchase the RAS material. The RAS specification would provide the technical specifications for the material quality.

AGENDA ITEM #5: UPDATE ON RAS SPECIFICATION

Katie Kennedy provided an overview of the review process.

- We've received comments from the health departments in King, Snohomish, and Pierce County; Washington State L&I, Puget Sound Clean Air Agency, and Washington State Department of Ecology.
- Key changes have been requiring that the facility be permitted to grind shingles and that they request a copy of the AHERA survey from the roofing contractor.
- Next steps are to check in with the three processors that responded to the RFI, share with roofing contractors for their comments, and email to the regulatory agencies for final review.
- Outstanding issues include the number and protocol for asbestos testing and whether to include WSDOT field operating procedures (FOPs) in the spec. Some commented that it may be best to simply include FOP citations and links as per the current draft RAS spec.

There was a discussion as to whether the spec is too narrow.

- The spec does set a precedent despite the project team's intention for it not to be, and the goal should be to educate local regulators on the testing that has been done across the country, such as those from Dr. Timothy Townsend (John Yeasting).
- The project team's goal is to identify and ensure the selected suppliers and contractors are operating within existing health and environmental regulations. The resulting draft RAS spec incorporates requirements that are specific to our region, which may differ in other states that are allowing the use of RAS in paving applications (Dan Krivit).
- Perhaps the permitting agency requirements should be removed and consolidated into a separate document (Frank Overton).

What about fire retardants in shingles (Kevin Kelsey)?
The LinkUp team has investigated whether fire retardants are a concern, and no evidence was found to that end. Also, the Washington State Department of Ecology considers RAS as an additive in paving to be a safe use of the material, and so does not require a beneficial use

determination (BUD). This is the primary basis on which LinkUp is considering RAS as safe to use in paving (Kris Beatty).

Why is the supply limited to owner-occupied, single-family homes (Bill Brickey)?
This is related to National Emissions Standards for Hazardous Air Pollutants (NESHAP) regulations, which are interpreted different by different states and local agencies (Dan Krivit). *(Clean Air Agency Regulation III, Section 4.02 makes a distinction between owner occupied and non-owner occupied homes. According to this rule, non-AHERA accredited persons are allowed to inspect owner-occupied, single-family roofs prior to demolition or renovation.)*

AGENDA ITEM #6: PROJECT DESIGN

RAP/RAS Approach

Kris reported that KCDOT, WSDOT and KCSWD recently met to discuss whether or not to include RAP in the project. Joe DeVol presented relevant preliminary testing data. *(Handout: WSDOT's RAS Research Project test results tables.)* Joe cautioned that the data being presented is very preliminary based on limited number of samples in response to the RFI. These tables are being used by WSDOT to develop their mix design calculation templates for incorporating RAS and RAP into mixes.

Joe reported that the total asphalt content of the RAS from the samples from the three respondents averaged 19.6 percent binder (indentified as "Pb" within the table "Gradation Averages") and ranged from a low of 16.3 Pb and a high of 22.8 Pb. This compares to the one RAP sample of 4.1 Pb.

One intent of the WSDOT mix design work is to estimate the effective contribution of recycled asphalt from the RAS and the RAP. Then the amount of added virgin liquid binder can be adjusted such that final calculated percent binder (Pb) always ends up at the targeted 5.5 Pb level for the final HMA product. *(See the "Volumetric Comparison" tables, under column "Pb".)*

Joe DeVol reported that the preliminary results indicated that air voids increased with the addition of RAS. Another interesting finding was that air voids decreased with the addition of RAP thus compensating somewhat for the RAS impacts on air voids *(See the "Volumetric Comparison" tables, under column "Va" for air voids.)*

Next, Joe plans to test the asphalt binders. We anticipate the asphalt in the RAP to be stiffer and RAS to be significantly stiffer. One option is to specify a softer-grade of liquid virgin asphalt to compensate for the harder RAS binder. With the instability in the asphalt market right now, though, we don't know if we can even get suppliers to provide a softer-grade of liquid virgin asphalt (e.g., PG 58-16), let alone how much it will cost.

Victor Woo calculated that 3% for the RAS and 15% for the RAP would provide an ideal amount of oil replacement and optimize the air void impacts. Most of the group concurred with this proposed breakdown.

Is the extraction test a realistic measure of the "effective contribution" (asphalt content actually utilized in the HMA drum in full production)?
The extraction tests are more accurate with RAS than RAP (Joe DeVol). The extraction tests measure "total" asphalt content within RAS or RAP or other materials. Only a portion of the total

will actually be utilized as asphalt in the HMA drum. Other research has estimated the effective contribution at 60 to 80 percent of the total asphalt content in the RAS.

Update on paving plan (test sections)

Originally, it was thought that the paving design layout would include four test sections: 1) virgin HMA, 2) HMA with RAS, 3) HMA with RAP, and 4) HMA with RAP and RAS. Victor explained that the design will be simplified to two test sections: 1) HMA with RAP, and 2) HMA with RAP and RAS. The goal is to prove that there's no difference between RAP and RAS in terms of quality.

Does the new test plan still require 30 tons of RAS (Dan Krivit)?
It will be 60 tons of RAS for 2,000 tons HMA (Frank Overton).

Will the test sections be side-by-side (John Grisham)?
No, we'll do consecutive paving on lanes going both directions so the traffic is the same (Victor Woo).

Miscellaneous
Will the market development effort be carried on beyond the publishing of the study report (Steven Read)?
Yes, the King County Solid Waste Division considers this demonstration project as a building block that is part of a larger effort to establish the HMA market for recycled asphalt shingles (Kris Beatty).

NEXT STEPS

- Distribute new pavement test section plan to advisory group
- Make final revisions to RAS spec and distribute to advisory group
- Continue WSDOT mix design tests and discussions to finalize HMA provisional specification

King County LinkUp Shingles in Paving Demonstration Project
Summary of Advisory Group Meeting #4, Thursday, December 3, 2009

These notes summarize the fourth and final meeting of the Advisory Group for the King County LinkUp Shingles in Paving Demonstration Project. The meeting was held on Thursday, December 3, 2009 at the King Street Center in Seattle, WA.

The following Advisory Group members participated:

- *Joe DeVol, WSDOT*
- *Paul Moore, KCDOT*
- *Hope Perkins, American Roofing Recyclers*
- *Al Corwin, KCDOT*
- *Preston Horne-Brine, Fluxion Enterprises*
- *Frank Overton, KCDOT*
- *Kevin Kelsey, KCDOT*
- *Gabriella Uhlar-Heffner, SPU*
- *David McAuley, CEMEX*
- *Jim Eagan, KCDOT*
- *John Grisham, Woodworth & Co.*
- *Rick Stewart, Stewart Roofing*
- *Steven Read, SDOT*
- *Jim Weston, WSDOT*
- *John Yeasting, Glacier Recycle*

The following project staff participated:

- *Kris Beatty, LinkUp, King County Solid Waste Division (KCSWD)*
- *Julie Colehour, King County LinkUp Consultant Support (Colehour+Cohen)*
- *Michelle Caulfield, Katie Kennedy, King County LinkUp Consultant Support (Cascadia Consulting Group)*
- *Dan Krivit, King County LinkUp Consultant Support (Foth Infrastructure & Environment) (via phone)*

The following Advisory Group members were absent but were given the opportunity to provide input and feedback on the draft meeting notes:

- *Ben Hansen, SDOT*
- *Bill Brickey, Granite Northwest*
- *Dick Lilly, SPU*
- *Jeff Uhlmeyer, WSDOT*
- *Rick Hess, PSCAA*
- *Victor Woo, KCDOT*

Meeting Objectives

- Provide project update; celebrate accomplishments
- Gather input for 2010 work plan
- Discuss strategies for documenting and communicating results

Key Outcomes

- Several ideas emerged as possible ways to further develop the market for shingles in paving as well as address concerns over using this material.

- Members generated a significant list of organizations, including some where they are members, to reach out to with presentations on the project.
- SPU and SDOT are interested in working with LinkUp to reach out to roofing contractors and may consider a paving pilot.

Agenda item #1: Welcome and Thank You

Photo slideshow of demonstration project phases. Kris Beatty presented tokens of appreciation to the group as well as the core project team.

Agenda item #2: Paving Accomplished!

Video and PowerPoint presentation including overview of project progress since the last advisory group meeting, materials and paving testing, and preliminary findings. Powerpoint and video will both be available on the King County LinkUp website.

Michelle Caulfield provided a project overview (Powerpoint); Kevin Kelsey and Joe DeVol summarized testing and findings.

- Pre-construction documentation included
    - walking the entire roadway to determine existing crack patterns and other deficiencies,
    - further documenting the surface using the WSDOT data distress collection van,
    - retrieving asphalt core samples to determine existing pavement structure, subsurface borings to determine subsurface conditions, and
    - Collecting deflectometer readings to provide additional structural testing.
- Preliminary materials testing of mix design was completed to effectively assess the impact of adding RAS to the mix. *Result tables are presented in the Powerpoint.*
- Testing during paving, which occurred during the week of 9/21/09, revealed that modifications were necessary to obtain the desired content for asphalt, fines, and voids. Following modifications, testing showed that the mix was in general compliance with the mix design.
- Post-construction testing included:
    - Collecting deflectometer readings to establish a structural baseline for the newly overlaid roadways.
    - Skid resistance testing in dry weather conditions that indicated little difference between test sections. All test sections have frictional values comparable to regular pavement throughout King County.
- KCDOT anticipates conducting the following tests and reporting of results.
    - The WSDOT data distress collection van will perform a post-construction run in the near future and again in three years.
    - Skid resistance testing will be completed under wet weather conditions in the near future and testing will be repeated after three years.
    - The road will be closely monitored for the next three years.
    - Pavement condition rating will be performed on a yearly basis.
    - A post construction report will then be produced.

John Grisham spoke to Woodworth's experience on the demonstration project.

- Woodworth sees the project as highly successful. They have been using asphalt shingles in HMA for many years, but learned a lot in working with a more stringent specification. One surprise was that double-grinding shingles appears to have resulted in a higher asphalt contribution from RAS to HMA.

Agenda item #3: Moving Forward

Current Plans & Ideas

Kris Beatty discussed immediate next steps for the project and initial ideas for 2010 activities.

- The final report will be completed in January. There will be an opportunity to review the report in early January. **Please contact Kris if you would like to review the draft report.**
- In late January, the LinkUp team will present pilot outcomes to the KCDOT Road Services management team.
- The LinkUp team will convene a broader stakeholder meeting in February to present pilot outcomes and discuss next steps. In addition, targeted outreach to specific stakeholders will occur throughout the year.
- The LinkUp team has begun talking to WSDOT about future strategies toward a provisional and/or permissive specification for using RAS in HMA.

Initial research needs to further advance the use of RAS in HMA:

- Conduct interviews to better understand how RAS is used on private roads in the Northwest.
- Investigate how much asphalt RAS is contributing to HMA. During the demonstration project, results indicated that RAS contributed a greater amount of asphalt than expected.
- Assess costs and savings from using RAS in HMA. This investigation would likely begin by working with Woodworth to collect actual cost savings incurred during the project.
- Work with national partners to develop standards for sampling and testing to determine the presence of asbestos in shingles.
- Review the RAS specification used in the demonstration project to determine what should be changed for future pilots.
- Work more directly with roofers on RAS supplies issues.

Group Discussion

The advisory group discussed ideas for 2010. The table at the end of this document summarizes key recommendations from advisory group members. Discussion highlights are presented below.

- Tear-off roofing scrap will likely increase in the future because cedar shakes are seldom used today, making composition shingles the most common residential roofing material, (Rick Stewart).
- Successful recycling market development requires that all the pieces come together in the right order. For this reason, SPU would be interested in working with LinkUp in coordinating with roofing contractors to seek their input and prepare them to supply composition shingles for recycling (Gabriella Uhlar-Heffner).
- One barrier to further market development is that regulations and formal trainings are not material-specific. NESHAP, for example, does not provide guidance specifically on shingles (Michelle Caulfield).
- Seattle may be interested in doing a pilot paving project, although it may work better to partner with another jurisdiction in order to get enough tons (Steven Read).
- In addition to other paving trials, LinkUp could support market development in several other ways, such as by advertising the asbestos-testing results and helping to increase awareness of what types of materials actually have asbestos (e.g., shingles patching). Additionally, it would be helpful to have an investigation of how to store material for shingle recycling so that there are safe and practical expectations of processors. In general, it is important to focus the discussion on the overall goal of conserving landfill space. (John Yeasting).

There was a discussion as to what the best strategy is for market development.

- There are three ways to increase the use of shingles in paving: through a mandate, which might cause government agencies to actually lose control and could backfire; through a state agency, but then the bid price increases; and through private industry, which, if private industry sees it as a profitable venture (i.e., an “asphalt extender”), then the DOTs can function on the administrative side, testing and monitoring pavement (Joe DeVol).
- Groups like Association of General Contractors (AGC) can help push the market from the private side better than DOTs (Jim Weston).
- Private industry would benefit from a cost-benefit analysis (Kevin Kelsey).
- It might be most effective to have a compromise in these strategies, possibly including environmental groups. It is okay to pay a little bit of a premium to do the right thing (Steven Read).

Summary of Group Discussion on 2010 Work Plan

2010 Things we should know about	How we should share results	2010 Next Steps
• WAPA Group Meeting (mid-year) • OR and Vancouver pilots • California testing of shingles for asbestos • Owens-Corning and Heritage Environmental partnership • Warm mix (as of 2010, all WSDOT projects can now be warm mix)	• Washington Asphalt Paving Association (WAPA) • National Asphalt Paving Association (NAPA) • Washington State Department of Ecology • Asphalt Roofing Manufacturer Association • Federal Highway Transit Association • CMRA national forum (did in 2009) • Presentation at Washington State Recycling Association • Local health jurisdictions (barrier for new shingles processors will be permitting until they are more comfortable) • National Roofing Contractors' Association • WA Roofing Contractors' Association (with Rick Stewart's help) • Environmental Building News article • Asphalt Paving Association of Washington (APAW) • UW Greenroads program, Steve Muench, • AGC • Technology Transfer – WDOT Newsletter	• Develop national asbestos protocols (even work with manufacturers who may be interested/able to change their product) with a focus on practical reality (sorting and testing) • Document a completed private road project with focus on cost benefit • Develop an education piece for roofers, possibly in conjunction with Jim Lindahl, MN expert who is designing training program. • Develop tip sheet that captures experience with project (for other project managers) • Steven Read will talk to Ben Hansen about a possible SDOT pilot, possibly in partnership with another jurisdiction • Look at unknowns. For instance, how well will this product being recycled in the future • Environmental story

Shingles in Paving Demonstration Project
Advisory Group Charter
October, 2007

Preface

King County generates 17,000 tons of asphalt shingle waste each year, 16,000 tons of which are disposed in a landfill. In order to address this problem, King County Solid Waste Division's LinkUp program has made asphalt shingles a priority material for recycling and is working to develop new markets for it. To achieve this goal, LinkUp is working in the community to conduct a paving trial that incorporates tear-off asphalt shingles into hot mix asphalt (HMA).

The American Association of State Highway and Transportation Officials is currently reviewing a provisional specification for the use of reclaimed asphalt shingles as an additive in HMA. Eight states (CT, GA, MA, ME, MN, MO, NY, SC) currently allow for the use of tear-off shingles in paving projects either through state DOT specifications or Beneficial Use Determinations (BUDs) and there is increasing interest by other states to learn more and investigate whether to follow suit.

King County's LinkUp team has determined that the HMA market for asphalt shingles is the most promising end-market. A demonstration would provide needed information to state and local transportation officials about the potential for their future use of recycled asphalt shingles in HMA.

Problem Statement

A large quantity of asphalt shingles generated in King County is being disposed in landfills. Transportation officials in Washington do not have first-hand experience and the necessary information to consider allowing the use of asphalt shingles in HMA.

Objective

Provide input, feedback, comment on key decision points and recommendations, in an advisory capacity to the LinkUp team to help ensure a successful paving trial that incorporates recycled asphalt shingles.

King County's Advisory Group Sponsorship

The LinkUp program is the sponsor of this advisory group. Kris Beatty will lead the advisory group with support from her consultant team. As the sponsor, LinkUp commits to:

- Support the work of the advisory group.
- Give serious consideration to the recommendations of the advisory group.
- Facilitate advisory group meetings and follow-up.
- Represent advisory group feedback, input, advice, recommendations, etc to the project planning and implementation team.
- Provide direction or decisions on issues raised by the advisory group.

As the sustaining sponsor, the LinkUp program expects:

- To be informed if a problem occurs that is beyond the advisory group's or advisory group member's ability to address in a timely fashion.
- For advisory group members to make every effort to attend all advisory group meetings and participate in discussions, whether they be by phone, email or in-person.
- Advisory group members to go to Kris Beatty when additional clarity or direction is needed.
- The advisory group will work within the defined charter unless the LinkUp program has specifically agreed to make changes.
- The advisory group will work efficiently, making effective use of time and resources.

Scope

The advisory group will work within the following scope:

- The work of the team is expected to be completed by the end of Fall 2008, but may extend to 2009.
- The advisory group will comment on key project decision points and documents through email and up to three in person meetings.
- The advisory group will provide input and review on project design, testing, and findings through the following activities:
    - Reviewing project goals and criteria for selecting specific projects to best meet project needs
    - Reviewing national research and assessing additional informational needs, if any
    - Recommending potential projects, screening proposed projects against criteria, and selecting the demonstration project that best meets project needs
    - Reviewing project specifications and testing protocols for both recycled asphalt shingles (RAS) and hot mix asphalt (HMA)
    - Reviewing and providing input on testing results and overall project findings

Advisory Group Members

The below list of advisory group members was updated January 2010.

Team Member	Affiliation
Bill Brickey	Granite Northwest, Inc.
Joe DeVol	Washington State Department of Transportation
Jim Eagan	King County Department of Transportation
John Grisham	Woodworth & Company, Inc.
Ben Hansen	Seattle Department of Transportation
Rick Hess	Puget Sound Clean Air Agency
Preston Horne-Brine	American Roofing Recyclers
Kevin Kelsey	King County Department of Transportation
Dick Lilly	Seattle Public Utilities
David McAuley	CEMEX
Frank Overton	King County Department of Transportation
Hope Perkins	American Roofing Recyclers
Steven Read	Seattle Public Utilities
Rick Stewart	Stewart Roofing
Gabriella Uhlar-Heffner	Seattle Public Utilities
Jeff Uhlmeyer	Washington State Department of Transportation
Jim Weston	Washington State Department of Transportation
Victor Woo	King County Department of Transportation
John Yeasting	Glacier Recycle

APPENDIX E. SAMPLING AND TESTING MATRIX

The testing matrix that guided the evaluation of the demonstration is presented in this appendix.

SE 416th Street RAS Demonstration Project: Summary of Tests Associated Costs

Schedule	ID #	Test or Survey Item	KCDOT Responsibilities	WSDOT Responsibilities	Contractor Responsibilities
June-Early August		**Documentation of Existing Pavement Conditions**			
	0	Stationing			
	1	Preconstruction pavement condition survey (PCS)	PCS survey and report.		
	2	WSDOT (Path Runner) “Survey Van”		Path Runner survey and report.	
	3	Preconstruction site reconnaissance	PCS survey and report		
	4	Core the roadway	Core samples (2 cores per lane/per test section = 16 cores total), report.		
	5	Subsurface evaluation	One (1) survey		
	6	Deflectometer testing		One (1) survey	
	7	Document pavement preparation operations	One (1) survey		
Early August		**Contractor’s Report and Preliminary RAS Processing**			
	8	Verification of RAS and RAP measuring or metering process used by Contractor.	Review Contractor’s process report and conduct field inspection.	Review Contractor’s process report and conduct field inspection.	Contractor to submit process report after pre-construction conference.
Early August		**Contractor Develops Traditional Virgin HMA Mix Design**			
	9	Contractor develops traditional virgin HMA mix design with representative materials			Contractor to develop traditional virgin HMA mix design and submit representative samples of aggregates to WSDOT for verification.
Mid August		**Final Grind and Preliminary RAS Sampling**			
	10	RAS gradation	Collect representative RAS samples during final grind site visit. Store until determination of need for verification.	Verify with representative sample in WSDOT lab if necessary.	Contractor to sample, test, and report results to KCDOT.
	11	RAS AC content		WSDOT to run AC as part of its RAS product quality verification tests.	
	12	RAS moisture	Collect representative RAS samples during final grind site visit. Store until determination of need for verification.	Verify with representative sample in WSDOT lab if necessary.	Contractor to sample, test, and report results to KCDOT.
	13	RAS extraneous waste materials content	Collect representative RAS samples during final grind site visit. Store until determination of need for verification.	Verify with representative sample in WSDOT lab if necessary.	Contractor to sample, test, and report results to KCDOT.
	14	RAS asbestos			Contractor to sample, test with independent lab, and report results to KCDOT (as per RAS specification).

Schedule	ID #	Test or Survey Item	KCDOT Responsibilities	WSDOT Responsibilities	Contractor Responsibilities
Early August		**Virgin Aggregates Verification Testing**			**Contractor to submit representative aggregate samples to WSDOT (as per test item #9 above).**
	15	Fracture Count		Process and test representative mineral aggregate stockpile samples.	
	16	Uncompacted Void Content		Process and test representative mineral aggregate stockpile samples.	
	17	Sand Equivalent		Process and test representative mineral aggregate stockpile samples.	
Early August		**Verification Testing of Traditional Virgin HMA Mix Design**			**Contractor to submit representative aggregate samples to WSDOT (as per test item #9 above).**
	18	Voids in Mineral Aggregate (VMA)		Verification testing of Contractor's mix design.	
	19	Voids Filled with Asphalt (VFA)		Verification testing of Contractor's mix design.	
	20	Dust to Asphalt Binder Ratio (D/A)		Verification testing of Contractor's mix design.	
	21	% Gmm @ Ninitial		Verification testing of Contractor's mix design.	
	22	% Gmm @ Ndesign		Verification testing of Contractor's mix design.	
	23	% Gmm @ Nmaximum		Verification testing of Contractor's mix design.	
	24	Moisture Susceptibility / Anti-strip Evaluation		Verification testing of Contractor's mix design.	
	25	Ignition Furnace Calibration		Verification testing of Contractor's mix design.	
		Develop HMA Mix Design (15% RAP + 3% RAS)			
	26	Perform same battery of tests as described in ID #15-25 but include RAP & RAS.		Develop RAP + RAS mix design based on Contractor's original virgin HMA mix design. Provide recommendation for adjustments to gradation and asphalt content.	Contractor to submit RAP samples to WSDOT. To be evaluated with representative mineral aggregate previously submitted per test item #9 above. Contractor may need to respond to WSDOT's mix design recommendations for the RAS + RAP test mix.
Mid August		**Final RAS Sampling**			
	27	RAS gradation & AC	Collect RAS samples (or RAS + RAP pre-blended samples) during final site visit immediately prior to use in HMA.	Test in WSDOT lab.	

Schedule	ID #	Test or Survey Item	KCDOT Responsibilities	WSDOT Responsibilities	Contractor Responsibilities
	28	RAS moisture	Collect RAS samples (or RAS + RAP pre-blended samples) during final site visit immediately prior to use in HMA.	Test in WSDOT lab.	
	29	RAS extraneous waste materials content	Collect RAS samples (or RAS + RAP pre-blended samples) during final site visit immediately prior to use in HMA.	Test in WSDOT lab.	
Mid to Late August		**Paving Demonstration QA/QC Testing and Monitoring**			
	30	Asphalt content and gradation.	One (1) set per lane/ per test section. 8 tests total.		
	31	Perform same battery of tests as described in ID #15-25	One (1) test per lane/per test section. 8 tests total.	Informational testing – theoretical. Specific gravity to be used for determination of in-place density.	
	32	In-place density test lots (KCDOT every 250 tons) = 16 test lots	Five (5) tests per lot/two (2) lots per lane/per test section. 16 lots total.		
	33	RAS sampling and testing set (gradation, moisture, extraneous waste materials content)	One (1) set per lane/per RAS/RAP test section. Four (4) sets total.		
	34	Smoothness	King County Inspector to verify following lay-down and compaction.		
	35	Core roadway (gauge correlation)	Core test Section #1 immediately after completion. Core test section #3 immediately after completion. Run bulk density tests for gauge correlations. 8 cores per section. 16 cores total.		
Mid to Late August		**Performance Graded Asphalt Binder (PGAB) Acceptance & Additional Tests**			
	36	Test for original binder properties		Samples taken during production from supply lines at asphalt plant.	
	37	Test for RTFO binder properties		Samples taken during production from supply lines at asphalt plant.	
	38	Test for PAV binder properties		Samples taken during production from supply lines at asphalt plant.	
	39	BBR		Bending beam rheometer (BBR) test to determine critical low temperature cracking point	
	40	DSR		Dynamic shear rheometer (DSR) test to determine high temperature point	

SE 416th Street RAS Demonstration Project: Summary of Tests Associated Costs

Schedule	ID #	Test or Survey Item	KCDOT Responsibilities	WSDOT Responsibilities	Contractor Responsibilities
Early September		**Post-Paving Tests and Analyses (immediately after paving)**			
	41	Pavement deflectometer testing		One (1) test	
	42	Skid resistance test	One (1) skid resistance test		
	43	Pavement Path Runner survey		One (1) report	
	44	Post-paving preliminary report	One (1) report		
December		**Final First Year Report**			
	45	Document final pavement (“As Built” plans)	One (1) report		
	46	First year final report	One (1) report		
2010+		**Long-Term Pavement Construction Survey**			
	47	Pavement Path Runner survey (annually thereafter through 2012)		One (1) report	

APPENDIX F. KING COUNTY CONTRACT C00455C09 INVITATION TO BID (ITB)

This appendix includes the following excerpts from the Invitation to Bid (ITB):

- Special Provisions General Requirements
- Special Provisions Section 1-02.1 Qualifications of Bidders,
- Special Provisions Section 1-09.8 Phase I Preconstruction Activities and Materials Testing
- Special Provisions Section 5-04 Hot Mix Asphalt PG 64-22 (with 15 percent RAP)
- Special Provisions Section 5-06 Hot Mix Asphalt PG 64-22 (with 15 percent RAP and 3 percent (RAS)) (New Section)
- Section 9-36 RAS Specification
- Appendix 1 Bidder's Responsibility Form
- Appendix 2 RAS Supply Verification Form
- Appendix 3 Selected Test Methods from WSDOT's Materials Manual
- Appendix 4 Summary of Required RAS Samples and Tests by Contractor
- Appendix 5 Process Report Outline
- Contractor's Submittal Check List from Appendix 9 Contractor's Submittals
- Contract Drawings

King County

SPECIAL PROVISIONS

SE 416th Street Overlay: Shingles in Paving Demonstration

Contract No. C00455C09
Project No. M78030

GENERAL REQUIREMENTS

INTRODUCTION

The following Special Provisions in conjunction with the 2008 Standard Specifications for Road, Bridge and Municipal Construction, issued by the Washington State Department of Transportation and the American Public Works Association, Washington State Chapter (Standard Specifications), and the 2007 King County Road Design and Construction Standards (KCRDCS), which were adopted by the King County Council, govern this Contract. These Special Provisions supersede the referenced portions of Standard Specifications. Where any provision of Standard Specifications is modified or deleted by these Special Provisions, the unaltered, remaining portions remain in full force and effect.

Copies of the Standard Specifications and KCRDCS are on file in the office of the County Road Engineer, Department of Transportation, Road Services Division, 2nd Floor, 201 South Jackson Street, Seattle, Washington, 98104-3856 where they may be examined.

Wherever reference is made in the Standard Specifications to the Secretary of Transportation or Engineer, such reference shall be construed to mean the King County Road Engineer or the County Road Engineer's duly authorized assistants.

IMPORTANT NOTES REGARDING THIS PROJECT

This is a paving project to demonstrate the use of recycled asphalt shingles (RAS) with reclaimed asphalt pavement (RAP) in hot mix asphalt pavement (HMA). As a demonstration project, King County's goals extend beyond the physical construction and overlay of the above noted roadway.

1. This ITB is issued by the King County Department of Transportation (KCDOT) for the purpose of selecting a paving contractor for the *SE 416th Street Overlay: Shingles in Paving Demonstration*. The King County Solid Waste Division (KCSWD) initiated the *Shingles in Paving Demonstration* to demonstrate the successful use of post-consumer RAS, together with RAP, in HMA. Use of 3 to 5% RAS, together with about 15% RAP, has been proven in other states to be the most successful mix ratio in HMA. This recycling application for RAS derived from tear-off asphalt shingle scrap recovers the value of asphalt, aggregates and fiber in shingles that would otherwise be wasted and land filled. The project is being implemented by KCSWD in partnership with KCDOT and the Washington State Department of Transportation (WSDOT) as a controlled study. The project includes specific material sampling and testing protocols to help fully document the performance of post-consumer RAS in HMA.
2. This is a demonstration project and long-term performance study of a recycled material. In order to meet the long-term goals of this demonstration project and to limit the number of variables being studied, it is essential that all means and methods involved in the manufacture and placement of HMA be consistent for all four pavement test

sections. The only variable will be the HMA mix. Therefore, the Contractor is hereby notified that the same means and methods, plant, equipment, and personnel shall be employed for all operations involved in the mixing, placement, and compaction of all four pavement test sections. The Contractor is required to provide the County with a minimum of two (2) working days prior written notice of any change in means and methods, plant, equipment, and personnel used on the project. The Contractor shall not be allowed to make any such changes without the County's prior written consent. See also Section 5-04 of these Special Provisions.

3. King County will share information about this demonstration project externally through reports, articles, video, Web page and presentations. As requested, the Contractor shall supply non-proprietary information to King County to help document the demonstration project. The Contractor shall allow photographs and videos to be taken throughout the production and paving process, while providing guidance to the cameraperson to avoid collecting images that would reveal proprietary information or trade secrets. Photographs and video will be used for project documentation and promotional and publicity purposes. King County will permit the Contractor to review all draft content (written and image) for proprietary information in advance of publication or distribution.

4. Bidders shall mark any and all pages of the bid documentation and associated submittals it considers proprietary or confidential accordingly. Once in the County's possession, all such information and documentation shall become the property of King County and may be considered public records under the Washington Public Records Act, RCW 42.17.250 et seq. or the Washington Trade Secrets Act and as such may be subject to public disclosure. It is the County's intent, to the extent permitted by law, to keep all such documentation confidential before or after execution of the Contract. If a public disclosure request is made for all, or a portion of, such bid documentation or associated submittals, the County will notify the Bidder submitting the documents of the request and allow the Bidder ten (10) calendar days to take, at its own expense, whatever action is necessary to protect its interests. If a bidder fails to obtain the necessary protections and apprise the County of such actions within said period, the County will release the documentation requested. Not withstanding the foregoing, all bidders who provide documentation or submittals under this advertised procurement process accept the procedures described above and agree that the County will not be responsible for or liable in any way for any losses that a bidder may suffer from the disclosure of information or materials to third parties.

5. Representatives from KCSWD, KCDOT and WSDOT comprise the Project Team. The Project Team, with help from a Project Advisory Group, produced the ***Specifications for recycled asphalt shingles (RAS) derived from tear-off asphalt shingle scrap*** (***RAS Specifications***) included as Section 9-36 of these Special Provisions. These specifications provide the technical standards required to source, grind, and test RAS material for the *SE 416th Street Overlay: Shingles in Paving Demonstration.* In addition, the Project Team produced the modified *HMA Specifications* included in Section 5-04 and 5-06 of these Special Provisions. These specifications provide the technical standards (e.g., mix ratios) for introducing RAS and RAP into HMA. The *RAS* and *HMA Specifications* outlined here are **not** intended to be used as permanent materials standards or ongoing specifications. The results of the 2009 paving demonstration project will help determine how such specifications will be developed in the future.

6. More background information about the *Shingles in Paving Demonstration* can be found at http://your.kingcounty.gov/solidwaste/linkup/shingles/paving-demo.asp.

DESCRIPTION OF WORK

This project provides for the improvement of approximately two miles of roadway in South King County by planing bituminous surfaces, removing raised pavement markers, rumble strips, and plastic traffic markings, paving with HMA mixes that include RAP and RAS, placing crushed surfacing, erosion control and other work, all in accordance with the attached Plans, these Special Provisions, the Standard Specifications, the KCRS, and the APWA/WSDOT Standard Plans for Road, Bridge, and Municipal Construction.

1-01 DEFINITIONS AND TERMS

1-01.3 DEFINITIONS

The definition for "Contracting Agency" is deleted and replaced with the following:

Contracting Agency

Agency of Government that is responsible for the execution and administration of the contract. Also means King County, Department of Transportation, Road Services Division.

The definition for "Engineer" is deleted and replaced with the following:

Engineer

The Contracting Agency's representative who administers the construction program for the Contracting Agency. Also means King County Road Engineer or the King County Road Engineer's authorized assistants.

The following definitions are added to this section:

Change Order

A document required by the Engineer which authorizes an addition, deletion, or revision in the Work, or an adjustment in the Contract Price or the Contract Time, issued on or after the effective date of the Agreement.

Contract Documents

The terms "Contract Documents" shall have the same meaning as Contract.

County

King County Department of Transportation (KCDOT), Road Services Division.

Notice to Proceed

The written notice by the County to the Contractor establishing the date on which the Contract Time will commence and on which date the Contractor shall be permitted to begin performance of the Contractor's obligations under the Contract Documents.

Performance and Payment Bond

The definition is the same as that provided for the term "Contract Bond." If a bond is submitted, the Contractor will be required to submit a performance and payment bond, in triplicate, on the County provided form within 10 calendar days of receipt of Notice of Selection.

Tear-off asphalt shingles (also referred to as "tear-off asphalt shingle scrap")

Previously used asphalt shingles derived primarily from re-roofing projects whereby the old shingle layers are removed to prepare the roof surface for new shingles and / or other roofing materials.

Reclaimed Asphalt Pavement (RAP): (sometimes referred to as "recycled asphalt pavement")

Ground, screened product derived from old bituminous paving surfaces. Alternative sources of RAP can include either: bituminous chunks of pavement (i.e., not milled); and / or millings from on-site grinding / reclamation equipment.

Recycled Asphalt Shingles (RAS)

The finished product derived from crushing, grinding, screening and otherwise processing tear-off asphalt shingles. RAS is most often processed into a form ready for use in hot-mix asphalt plants.

Paving Contractor" (or "Contractor")

The company, under contract to the Contracting Agency, which will be responsible for securing a supply of recycled asphalt shingles (RAS) meeting the RAS Specification (Section 9-36), and installing overlay conventional and RAS-modified hot mix asphalt paving for the *SE 416th Street Overlay: Shingles in Paving Demonstration.*

Asphalt Shingle Recycling Operator (or "Shingle Recycling Operator")

The company, or companies, that receive tear-off asphalt shingle scrap, transform it into a finished RAS product and supply it to the Contractor. The Contracting Agency understands that the Contractor may also be the Shingle Recycling Operator.

Asphalt shingle recycling facility (or "Recycling Facility")

The physical plant (or plants) where tear-off asphalt shingles are received, processed into a finished RAS product, tested and stockpiled. This may include separate transfer locations.

Asbestos containing material (or "ACM")

Any material containing more than 1% asbestos as defined by WAC 296-62-07703.

1-02 BID PROCEDURES AND CONDITIONS

1-02.1 PREQUALIFICATION OF BIDDER

This section is deleted in its entirety and replaced with the following:

1-02.1 QUALIFICATIONS OF BIDDER

Responsibility Evaluation

The Bidder shall demonstrate to the satisfaction of King County that the Bidder's team is qualified to perform the work under this Contract and therefore responsible. For the Bidder's team to be responsible, the Bidder, Shingle Recycling Operator, Paving Contractor, and designated key personnel must demonstrate an appropriate level of experience, technical competence, and successful past performance of work. An entity of the Bidder's team may perform more than one function. The information requested in this section will assist the County in making such determination.

In the event King County finds the Bidder's qualification information lacking or if the County determines that the Bidder, Shingle Recycling Operator, Paving Contractor and/or project team member(s) are not qualified, the County may reject the Bidder, meet with the Bidder, or request additional information. Timeliness of Contract Execution is critical to success of this project; therefore, the County may give a Bidder limited or no opportunity and time to remedy a matter(s) of responsibility before rejecting the bid and going to the next low bidder. Such decisions are the sole discretion of the County.

King County reserves the right to contact references and investigate past performance and qualifications of the Bidder, Shingle Recycling Operator, Paving Contractor and project team members, including contacting third parties and/or the references provided by the Bidder. References may be asked to describe their experience with project team members, Shingle Recycling Operators, Paving Contractors, the Bidder, and/or members of the Joint Venture (JV) or other similar Business Organizational Structure (BOS) such as a partnership or limited liability partnership. Information may be solicited and evaluated on the following subjects: type and features of work; overall quality of project performance and quality of work; experience and technical knowledge and competence of the Bidder and Project Team Members; ability, capacity and skill to perform the Work; compliance with laws, ordinances, and contract provisions; and other information as deemed necessary by the County. Poor reference(s) may be justification to determine a Bidder is not responsible.

For this requirement, the term Bidder includes: (i) the legal entity that signed this bid; or (ii) any member of the JV or BOS provided the member was responsible for managing the day-to-day administrative activities for the referenced projects and is responsible for management of day-to-day activities of this contract.

To assist King County in the review of the Bidder's qualifications, the Bidder shall provide the information requested below.

A. The Bidder shall demonstrate that its team possesses the following required elements of responsibility:

1. Own and operate the HMA plant proposed for use on this project;
2. The ability and capacity of the HMA plant proposed for use on this project to precisely control (a) the relative ratio of the RAP percentage by weight and (b) the relative ratio of the RAS percentage by weight, as these two materials are incorporated into the two HMA mixes;
3. Successfully paved a minimum of 10,000 tons of HMA on public roadway projects (either new construction or maintenance overlay), incorporating a minimum of 1000 tons of RAP in the HMA mix, within the last two years;
4. A minimum of six (6) months of experience researching, experimenting, testing, producing, and evaluating each of the following: (a) RAS Material; (b) RAS incorporated into HMA mix for paving.
5. Successfully completed one or more paving project with a combined total of at least 500 tons of HMA mix that includes the controlled use of RAP and RAS. The HMA need not have been produced at the HMA plant proposed for this project.
6. An accredited Asbestos Hazard Emergency Response Act (AHERA) inspector on the staff of, or under contract to, the Asphalt Shingle Recycling Operator to inspect for ACM in incoming loads of tear-off asphalt shingle scrap to be used to produce the final RAS product for this project.
7. The Asphalt Shingle Recycling Operator has the necessary capacity to: (1) receive and store new tear-off asphalt shingle scrap; (2) process the scrap, and; (3) store it in a separate stockpile from other materials.
8. Ability to meet the time limits identified in the Contract.

B. The Bidder shall also demonstrate or provide:

1. How it shall self perform work equivalent to at least 70 percent of the Contract Price. The Bidder shall demonstrate this by identifying the work using the specification divisions or sections within a division it intends to perform with its own forces and the estimated dollar amount and percentage to its overall bid amount this itemized work constitutes.
2. A brief description of the applicable work experience with the elements identified in Section A above for the following key project team members :
    i. Project Manager
    ii. Project Superintendent, if different than the Project Manager
    iii. Designated HMA Plant Operator
    iv. Designated Asphalt Shingle Recycling Facility Operator
    v. AHERA Accredited Inspector
    vi. Road Paving Lead

    The above project team members shall be considered Key Personnel and shall actively participate in the project for the duration of the project unless replaced with another person with similar experience. Such replacements shall be approved by the Engineer.
3. Provide a preliminary project schedule which demonstrates the Bidder's management and understanding of the Contract Work. Provide a schedule in sufficient detail to demonstrate how the Bidder expects to comply with the Contract Milestones and the Substantial Completion date. Include at least the following:
    a) Activities identified as part of Phase I Preconstruction Activities and Materials Testing found in Section 1-09.8 of these Special Provisions.
    b) Activities identified as part of Phase II Construction Paving found in Section 1-08.3 of these Special Provisions.
    c) Substantial Completion.

d) Physical Completion

4. Provide the following environmental compliance documentation from the Shingle Recycling Operator for the Asphalt Shingle Recycling Facility proposed for use on this Contract: Either of the following:
   a) Solid Waste Handling Permit Number and a copy of the section of the Plan of Operation, approved by the local health jurisdiction, that describes asphalt shingle processing; **or**
   b) Copies of the Recycling or Material Recovery Facility Notice of Intent to Operate under Terms and Conditions for Solid Waste Permit Exemption and the corresponding approval letter from the local health jurisdiction for the Solid Waste Permit Exemption.
5. The Bidder shall provide a copy of any official documentation which reflects any written warnings or violations of any local, state, or federal environmental or solid waste laws or regulations within June 2008 to the present.
6. The County will evaluate to determine if the Bidder's contract history demonstrates quality of past performance and the capability to successfully manage and construct this Project.
   a) Identify if within the past 5 years that the Bidder or, if the Bidder is a JV or BOS, any member of the JV or BOS has:
   b) Had a contract terminated for cause or default;
   c) Has been (a) convicted of a willful violation or (b) issued a willful violation citation by Department of Labor & Industries, or similar organization with jurisdiction in the United States;
   d) Not been an active contractor;
   e) Been in bankruptcy, reorganization and/or receivership;
   f) Not been registered and licensed as a construction contractor;
   g) Been disqualified by any federal, state or local agency from being awarded and/or participating in public contracts.
   h) Explain the circumstances surrounding the event identified above.
7. The County will evaluate to determine if the Bidder's criminal history demonstrates inappropriate character, integrity, reputation, judgment, and experience of the Bidder. Identify all criminal convictions, including pleas of nolo contendere, of the Bidder and any officers of the Bidder. If the Bidder is a JV or BOS, provide all information for each member of the JV or BOS.
8. Submit the Bidder's accident/injury experience factor from the Department of Labor and Industries or other appropriate organization from the year 2005 to present. If the Bidder is a joint venture, provide information for members of the joint venture who will be performing and managing the Contract work. If a JV or BOS partner is only providing financial support, this information is not required and will not be evaluated with regard to this element.
9. At the County's request, provide any additional explanation or information, which would assist in evaluating the qualifications of the Bidder, subcontractors, project team members, JV or BOS members, and bid price.

Submittal Instructions

1. The apparent low bidder and second low bidder shall submit qualification information within 3 business days from the County's request for qualification information. The County may at its sole discretion grant Bidder additional time to provide information if the circumstances justify such extension.
2. Qualification information as outlined in Sections A and B under Responsibility Evaluation above, shall be submitted on the Bidder's Responsibility Form located in the Appendix 1. Submittal provided shall be legible and in a clear, comprehensive and concise manner. Submit one (1) unbound original. The original shall be indexed with tabs for each item, using recycled, white, 8½"x11" paper where possible, and a minimum font size of ten points. The cover sheet shall include this Contract Title, Contract Number, Bidder's name, mailing address, contact person, email address, telephone, and fax number.

Liquidated damages in the amount of $500 per working day will be assessed for Contractor's failure to Physically Complete the Preconstruction Activities and Material Testing Phase within the number of working days specified.

Liquidated damages in accordance with the Liquidated Damages Formula noted in this section will be assessed for Contractor's failure to Physically Complete the Construction Paving Phase within the number of working days specified.

1-09 MEASUREMENT AND PAYMENT

1-09.2(1) GENERAL REQUIREMENTS FOR WEIGHING EQUIPMENT

The following is added to the end of this section:

The Contractor shall notify the Engineer not less than one working day prior to delivering materials measured and paid for by weight on the project. Certified weights must be issued at the source.

The contractor shall provide a licensed public weighmaster. The licensed weighmaster shall issue weight tickets to the truck driver for acceptance of the material on the project by a County representative. No materials measured and paid for by weight will be accepted without certified weight tickets from a platform scale in accordance with Section 1-09.2(3).

Truckloads must conform to legal load limits. In case of overload, the difference between overload and maximum legal load will not be paid for. If there are repeated instances of overloading, the proper enforcement authorities will be notified.

1-09.7 MOBILIZATION

This section is deleted in its entirety and replaced with the following:

Mobilization consists of the expenses and costs of preparatory work and operations performed by the Contractor (except those preconstruction activities identified in 1-09.8 below). Mobilization shall be included in the various bid items in the contract; no further compensation will be made.

1-09.8 PAYMENT FOR MATERIAL ON HAND (SECTION DELETED AND REPLACED)

This section and its title are deleted in its entirety and replaced with the following new section:

1-09.8 PHASE I PRECONSTRUCTION ACTIVITIES AND MATERIALS TESTING (NEW SECTION)

This work shall include all preconstruction activities (except mobilization) and materials testing performed during the Phase I Preconstruction Activities and Materials Testing Phase as identified in Section 1-08.3(1) of these Special Provisions and also includes the following items of work:

1. **Process Report:** The Contractor shall prepare and submit a detailed report for review and acceptance by the County documenting all the steps it will undertake in the preparation, processing, and placement of the RAS/RAP HMA pavement as required and specified by this Contract. An outline of the elements required and the minimum submittal requirements are included in Appendix 5 of this document. (An electronic version of the report outline will be provided to the selected contractor for their use when this contract is awarded.) The initial draft of this report shall be submitted no later than three working days after the Notice to Proceed for Phase I. King County will review the draft and provide comments and supplemental questions to the Contractor within three working days. A final version of the Process Report deemed Acceptable to the County shall be required within the contract time limits specified for Phase I of the Contract.

2. The Contractor shall complete all Preconstruction Activities including RAS Material Testing and Approvals identified in Section 9-36 of these Special Provisions and in the table entitled ""**Summary of Required RAS Samples and Tests by Contractor**"" located in Appendix 4.
3. The Contractor shall submit all required project submittals indentified in the Contract including Appendices for review and acceptance by the County.
4. The Contractor shall conduct all project processing plant tours (Recycling Facility Operations, HMA Plant Operations, RAS Final Grind Operations, RAS/RAP Blending Operations, required by this Contract.
5. The Contractor shall conduct all tests required by this contract and shall submit all test results, material samples, and mix designs as required by this Contract.
6. Secure all required County Acceptance and Approvals for Materials and Processes.
7. Complete Pre-Paving Meeting with County Staff.
8. All other preparatory and miscellaneous preconstruction work required to perform Phase II of this Contract including providing the County with access to observe the Final RAS/RAP HMA mixing on all paving days.

All costs for completing Phase I work shall be included in the lump sum bid item entitled "Preconstruction Activities and Material Testing." No further compensation will be made to the Contractor for Phase I work.

Phase II Construction Paving Phase activities are identified throughout the remainder of this contract. All costs for completing items of work identified in Phase II shall be in accordance with the Measurement and Payment Sections of the various items.

1-09.9 PAYMENTS

The fifth paragraph is deleted and replaced with the following:

Upon completion of all work and after final inspection (Section 1-05.11), the amount due to the Contractor under the Contract will be paid based upon the final estimate made by the Engineer and presentation of a Comparison of Quantities signed by Contractor. Such voucher shall be deemed a release of all claims of the Contractor unless a claim is filed in accordance with the requirements of Section 1-09.11 and is expressly excepted from the Contractor's certification on the Comparison of Quantities.

1-09.9(2) COUNTY'S RIGHT TO WITHHOLD AND DISBURSE MONIES DUE (NEW SECTION)

In addition to monies retained pursuant to RCW 60.28, the Contractor authorizes the County to withhold progress payments due or deduct an amount from any payment or payments due the Contractor that, in the County's opinion, may be necessary to cover the County's costs for or to remedy the following situations:

1. Failure of the Contractor to submit and obtain approval of a progress schedule.
2. Failure of the Contractor to remedy defective work.
3. Failure of the Contractor to provide the Engineer with a field office when required by the Special Provisions.
4. For overtime work performed by County personnel.
5. Lack of construction progress which, based upon the Engineer's review of the Contractor's approved progress schedule, indicates that the work will not be physically completed within the Contract time. When calculating an anticipated time overrun, the County will make allowances for weather delays, approved unavoidable delays and suspensions of the work. The amount withheld under this subparagraph will be based upon the liquidated damages amount per day set forth in these Special Provisions multiplied by the number of days the Contractor's approved progress schedule, in the opinion of the Engineer, indicates the Contract may exceed the Contract time.
6. Damage to another Contractor when there is evidence thereof and a claim has been filed.

2-02.1 DESCRIPTION

The following is added at the end of this section:

In reference to this section, plastic pavement markings, rumble strips, and raised pavement markers shall be removed in accordance with Section 8-22.3(7), just prior to paving, and disposed of by the Contractor.

2-02.5 PAYMENT

The following is added at the end of this section:

"Removing Plastic Traffic Markings, Rumble Strips, and Raised Pavement Markers", lump sum.

PRODUCTION FROM QUARRY AND PIT SITES AND STOCKPILING

3-02 STOCKPILING AGGREGATES

3-02.2(1) STOCKPILE SITES PROVIDED BY THE CONTRACTING AGENCY

This section is deleted in its entirety and replaced with the following:

No stockpile will be provided by the County.

3-03 SITE RECLAMATION

3-03.2(1) CONTRACTING AGENCY-PROVIDED SITES

This section is deleted in its entirety and replaced with the following:

No site will be provided by the County.

5-04 HOT MIX ASPHALT PG 64-22 (with 15 percent RAP)

5-04.2 MATERIALS

The third paragraph is deleted in its entirety and replaced with the following:

The Contractor shall utilize RAP in the production of HMA. The amount of RAP shall be 15 percent plus or minus one-half of one percent of the total weight of aggregate in the mix. The RAP may be from pavement removed under the Contract or pavement from an existing stockpile.

The first sentence of the fourth paragraph is deleted and replaced with the following:

The grade of paving asphalt shall be PG 64-22.

5-04.3 CONSTRUCTION REQUIREMENTS

The following is added to the beginning of this section:

Important Note Regarding This Project: This is a demonstration project and long-term performance study of a recycled material. In order to meet the long-term goals of this demonstration project and to limit the number of variables

being studied, it is essential that all means and methods involved in the manufacture and placement of HMA be consistent for all four pavement test sections. The only variable will be the HMA mix. Therefore, the Contractor is hereby notified that the same means and methods plant, equipment, and personnel shall be employed for all operations involved in the mixing, placement, and compaction of all four pavement test sections.

5-04.3(2) HAULING EQUIPMENT

The second sentence of the first paragraph of this section is deleted and replaced with the following:

Haul trucks **shall be tarped at all times** no matter the weather or travel distance to the project, the canvas cover shall be securely attached to protect the HMA. The trucks and trailers shall remain covered until the HMA is transferred to the material transfer device or vehicle and into the paving machine.

5-04.3(3) HOT MIX ASPHALT PAVERS

The following is added at the end of this section:

For this project, the direct transfer of the HMA from the hauling equipment to the paving machine **will not be allowed**. A material transfer device or vehicle (MTD/V) shall be used to deliver the HMA from the hauling equipment to the paving machine. The MTD/V shall be Roadtec SB-1500D or Engineer approved equivalent equipment. **For this project, a windrow elevator shall not be used as a MTD/V.**

The MTD/V shall mix the HMA after delivery by the hauling equipment but prior to lay down by the paving machine. Mixing of the HMA shall be sufficient to obtain a uniform temperature throughout the mixture.

5-04.3(5)A PREPARATION OF EXISTING SURFACE

The third paragraph of this section is deleted and replaced with the following:

Equipment shall not operate on tacked surfaces until the tack has broken and cured. If the Contractor's operation or weather damages the tack coat it shall be repaired at no cost to the contracting agency prior to placement of the HMA.

5-04.3(5)E PAVEMENT REPAIR

The eighth paragraph of this section is deleted and replaced with the following:

Placement of the HMA backfill shall be accomplished in lifts not to exceed 0.25 foot compacted depth. Each lift shall be thoroughly compacted by a mechanical tamper or a roller.

5-04.3(5)F SHOULDER RESHAPING AND CRUSHED SURFACING MATERIAL (NEW SECTION)

Reshaping of shoulders will be performed by King County prior to the HMA overlay operations. The Contractor shall place and compact crushed surfacing material to the newly established line and grade, or as directed by the Engineer, within ten working days after the HMA overlay has been completed for each roadway segment. In addition to this general requirement, the Contractor shall have crushed surfacing material available for spreading as the Engineer directs to match the abrupt pavement edge at certain driveway locations; the Contractor shall place and compact crushed surfacing material at these locations within two working days of the Engineer's order. The Engineer may permit windrowing or end dumping method of placing the crushed surfacing material. The Contractor shall use a pick-up sweeper and shall dispose of debris off site.

Liquidated damages, in accordance with Section 1-08.9 of these specifications, will be deducted from monies due the contractor for failure to physically complete the shoulder/driveway crushed surfacing material placement and compaction portion of the contract within the completion time specified.

5-04.3(7)A Mix Design

Under Item 2, the fifth sentence of the first paragraph is deleted and replaced with the following:

A response will be provided within 14 calendar days after a mix design submittal has been received in the Contracting Agency's laboratory.

5-04.3(8) MIXING

Delete the first two sentences of the second paragraph and replace with the following:

When discharged the temperature of the HMA shall not exceed the maximum mixing temperature recommended on the mix design unless a higher maximum temperature is permitted by the asphalt binder manufacturer. The higher recommended temperature shall be the maximum temperature allowed. A maximum water content of 0.5 percent in the mix at discharge will be allowed providing the water causes no problems with handling, stripping, or flushing.

In the third sentence of the second paragraph, delete reference of Project Engineer and replace with Engineer.

5-04.3(8)A ACCEPTANCE SAMPLING AND TESTING – HMA MIXTURE

The following sections are modified or deleted as noted.

3. Sampling

Delete the entire section and replace with the following:

Samples for acceptance testing shall be obtained by the Contractor when ordered by the Engineer. Samples for acceptance testing will be obtained from the hauling vehicle. The Contractor shall provide adequate platforms to enable samples to be obtained. The platforms shall allow the sample to be taken without the Engineer entering the hauling vehicle. Samples will be obtained in accordance with King County Materials Laboratory's (KCML) procedure KC-D979.

The County will acquire samples at the frequency specified in Part B, as shown below. All samples acquired by the County or its agents are to be considered sufficiently representative to be analyzed statistically. Specifically, the County is not required to use a system relying on the use of randomly generated numbers to determine sampling locations or times. By entering into Contract, the parties bound by it, agree that KCML's sampling methods are sufficiently random and representative and are to be used as a basis for statistical acceptance as directed by these Specifications.

5. Test Results

Delete the first sentence in the first paragraph and replace with the following:

The Engineer will furnish the Contractor with the results of all testing, with the exception of the volumetric results, within 24 hours of sampling. Volumetric results will be reported within 48 hours.

Delete the third sentence in the first paragraph and replace with the following:

The CPF for the entire lot produced to date will be provided within 48 hours of sampling.

Delete the item Va Percent Va±0.7 from the Deviation Table.

6. Test Methods

Delete the entire section and replace with the following:

Testing of HMA for compliance of volumetric properties (VMA, VFA and Va) will be as per AASHTO T 312, "Preparing and Determining the Density of Hot Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor." ASTM D2726, "Bulk Specific Gravity of Compacted Bituminous Mixtures Using Saturated Surface-Dry Specimens." AASHTO T 209, Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures "Rice Density." Testing for compliance of asphalt binder content will be per ASTM D6307. Testing for compliance of gradation will be per AASHTO T30. AASHTO T329, "Moisture Content of Hot Mix Asphalt (HMA) Oven Method" will be used to determine the moisture content.

5-04.3(10)B CONTROL

Item 1. General

The reference to WSDOT FOP will be deleted and replaced with KCDOT SOP.

The reference to FOP for WAQTC TM 8 and WSDOT SOP T 729 will be deleted and replaced with KCDOT TM N-1.

Delete the fourth sentence in paragraph one.

Delete entire paragraph for item **1 a. Cyclic Density**.

Item 2. Test Section – Compaction

Reference to PE shall be deleted and replaced with Engineer.

Item 3. Test Results

Reference to PE shall be deleted and replaced with Engineer.

The reference to WSDOT Test Method No. 716 will be deleted and replaced with KCDOT SOP.

Delete rate of $125 per core and replace with, "current King County rate per core".

The following is added to the end of this section:

For HMA overlays that are being paved on existing or repaired asphalt, the following shall apply: The Engineer has the discretion to remove from the pay lot any compaction lots that fail to meet compaction specifications due to objectionable or unstable underlying sub-grade or surface defects

The HMA lay-down temperature shall be between 260°F and 325°F, unless the Asphalt Binder Manufacturer, the RAS Supplier, and the Engineer permit a higher mixing temperature. In this case the recommended maximum temperature shall be the maximum lay-down temperature allowed.

5-04.3(10)C CONTRACTOR'S RESPONSIBILITY (NEW SECTION)

The Contractor will be responsible for all compaction quality control testing during placement of the HMA under these items. The Contracting Agency's compaction testing and materials sampling will be for acceptance purposes.

The Contractor shall provide qualified compaction quality control services for continuous monitoring of the compaction process in order to verify that the minimum compaction requirements are being maintained throughout each paving day. All test results shall be adequately documented. No placement of materials for items covered by this specification will be allowed without the Contractor's quality control testing personnel on site. Testing by the Contracting Agency shall be for final acceptance and payment purposes only for each day's paving. The Contracting Agency may contract this testing out to an accredited independent laboratory.

The Contractor shall undertake the following steps to ensure compaction control.

1. The Contractor shall submit a draft Compaction Control Plan (CCP) specific to this project for review and acceptance by the contracting agency. The Plan shall detail how continuous monitoring and quality control shall be achieved. The initial Plan shall be submitted at least one week prior to the commencement of paving for review, comment and any final revisions to be made for resubmission in final form.

2. The CCP shall identify a person of authority – Compaction Foreman - whose sole responsibility is to oversee and ensure that the Specification compaction requirements are met throughout the paving duration. This person shall have 5 years experience related to and a thorough knowledge of the compaction process. This person shall be identified in the CCP by name. The Compaction Foreman's duties and responsibilities include the following:

    - Make changes to the compaction train as necessary to maintain or improve density results.
    - Direct the Contractor's Testing Technician as necessary regarding the location and frequency of compaction testing.
    - Tabulate test results derived from Contractor's Testing Technician and provide copies to the Inspector within 24 hours.
    - Monitor mat temperature and correlate with compaction effort as necessary.
    - Ensure that the rollers comply with Section 5-04.3(4) at all times and periodically check roller speeds through a Control Plan verification method.
    - Have the authority to change / regulate the Contractor's paving operation as necessary to meet the compaction specification.
    - Be on-site overseeing the compaction process at all times during paving
    - Ensure the paving rate does not exceed the capabilities of the compaction train.
    - Stop paving operations if remedial actions for failing test results do not bring subsequent density tests up to acceptable range.
    - Report throughout the day the compaction status to King County's Field Inspector
    - Submit Field HMA compaction reports to the Contracting Agency by noon of the next day after paving.

If the Contracting Agency's compaction test results show 2 or more failing lots in a day's paving or 2 failing lots in two consecutive paving days, the Contractor shall submit directly to the Engineer a revised CCP, prior to any subsequent paving days, indicating additional controls to be utilized in order to improve compaction results

For HMA Classes 1 inch, ¾ inch, ½ inch, and ⅜ inch, where the specified compacted course thickness is greater than 0.10 foot, the minimum acceptable level of compaction shall be 92 percent of the maximum density as determined by King County Materials Laboratory (KCML) Test Method N-1. The reference maximum density shall be determined as the moving average of the most recent five determinations for the HMA being placed. The specified level of compaction attained will be determined by the statistical evaluation of not less than five nuclear density gauge tests taken in accordance with KCML TM N-1 on the day the mix is placed, after completion of the finish rolling, at locations selected by the Engineer or as determined by the stratified random sampling procedures conforming to WSDOT TM 716 with each density sublot Each sublot will be between 200 and 600 tons, or a minimum of five nuclear density gauge tests for a single day's production, depending upon the tonnage quantity placed or tester availability for each project. The final lot each day may be increased to a maximum of 600 tons.

Control lots not meeting the minimum density standard shall be removed and replaced with satisfactory material. At the option of the Engineer, material that does not comply with the minimum density standard may be accepted at a reduced price.

Cores may be used as an alternate to the nuclear density gauge tests. When cores are taken by the Engineer at the request of the Contractor, the request shall be made by 12:00 P.M. (noon) of the first working day following placement of the mix. The County shall be reimbursed for the coring expenses at the King County Materials Laboratory's current billing rate per core when the core indicates the acceptable level of compaction within a lot has not been achieved.

At the start of paving, if requested by the Contractor, a compaction test section shall be constructed to determine the compatibility of the mix design and equipment used. Compatibility shall be based on the ability of the mix to attain the specified minimum density (92% of the maximum density determined by King County TM N-1). The Contractor shall be responsible for the control of the compaction effort. If the Contractor does not request a test section, the mix will be considered compactable.

HMA Classes 1-inch, ¾-inch, ½-inch and 3/8-inch constructed under conditions other than those listed above shall be compacted on the basis of a test point evaluation of the compaction train. The test point evaluation shall be performed in accordance with the instructions from the Engineer. The number of passes with an approved compaction train required to attain the maximum test point density shall be used on all subsequent paving

HMA for pre-leveling shall be thoroughly compacted. HMA that is used for pre-leveling wheel rutting shall be compacted with a pneumatic tire roller unless otherwise approved by the Engineer.

In addition to the randomly selected locations for tests of the control lot, the Engineer reserves the right to test any area that appears defective and to require the further compaction of areas that fall below acceptable density readings. These additional tests shall not affect the compaction evaluation of the entire control lot.

5-04.3(10)D FEATHERING HOT MIX ASPHALT (NEW SECTION)

Where directed by the Engineer, the Contractor shall feather the HMA in a manner to produce a smooth riding connection to the existing pavement.

After application of the tack coat of asphalt, the area of the feathered joint shall be preheated using hand torches. The preheating operation shall continue during the raking process to ensure a smooth and well-bonded joint.

HMA, utilized in the construction of the feathered connection to the existing pavement, shall be modified at the Contractor's plant or the commercial source from which the Contractor obtains the mix or by raking the joint, thereby removing the larger coarse aggregate, to the satisfaction of the Engineer.

Transverse joints shall be sealed with PG 58-22 or an approved equivalent grade of asphalt as directed by the Engineer.

All costs and expenses in connection with providing, placing and feathering the HMA and sealing with PG 58-22 or an approved equivalent shall be included in the unit price per ton for "HMA Cl. __PG __" and no additional compensation will be made.

5-04.3(13) SURFACE SMOOTHNESS

The second sentence of this section is deleted and replaced with the following:

The completed surface of the wearing course shall not vary more than 1/4 inch from the lower edge of a 10-foot straightedge placed on the surface parallel to centerline.

5-04.3(14) PLANING BITUMINOUS PAVEMENT

The first paragraph of this section is deleted and replaced with the following:

Planing shall be performed in a manner such that the underlying pavement is not torn, broken or otherwise injured by the planing operation. The surface of the underlying pavement shall be slightly grooved or roughened sufficiently to ensure a bond when overlaid. In existing single layer pavements, care shall be taken that the planing does not penetrate into the subgrade. The Engineer will determine the planing depth in these situations. The Contractor shall immediately remove from the project any worker who continuously and carelessly punctures the existing pavement with the planing equipment. Pavement outside the limits shown in the Plans or designated by the Engineer that is damaged by the Contractor's operations shall be repaired to the satisfaction of the Engineer, at the Contractor's expense.

The following is added at the end of this section:

Pavement shall be planed as designated in the Plans, or as directed by the Engineer.

The Contractor shall coordinate planing and paving operations so that no planed area is left unpaved for more than five working days. Planing of bridge approaches shall be done on the same day as paving, unless previously approved by the Engineer. When approval is granted by the Engineer to pre-plane bridge approaches, the Contractor shall place a paper joint asphalt wedge at the bridge approach. The wedge dimensions shall be as directed by the Engineer. Removal of the asphalt wedge for final paving shall occur within five working days. All costs for installing and removing the asphalt wedge shall be included in the unit price for planing bituminous pavement. Liquidated damages, in accordance with Section 1-08.9 of these specifications, will be deducted from monies due the Contractor for failure to pave the roadway after planing within the time specified.

5-04.3(22) HOT MIX ASPHALT FOR PRE LEVELING (NEW SECTION)

HMA shall be placed to pre level the existing roadway as shown on the typical roadway sections in the Plans in accordance with Section 5-04.3(5) of the Standard Specifications in those areas directed by the Engineer.

The pre level material shall be placed on the roadway to restore the pavement grade and cross section by filling dips, sags, wheel ruts and distorted areas within the roadway limits to be paved. The existing average slope from centerline for the roadway section shall be maintained.

Pre leveling will be performed only where directed by the Engineer.

All costs for furnishing materials, labor, tools and equipment to prelevel the existing roadway shall be included in the unit contract price per ton for the applicable type of HMA used for the paving section (i.e. "HMA Cl. __ PG __") and no additional compensation will be made.

5-04.3(23) ASPHALT BERM (NEW SECTION)

Where directed by the Engineer, the Contractor shall construct an asphalt berm at the pavement edge, or any other area designated by the Engineer, for drainage control. The berm dimensions, including height, length and thickness will be field determined by the Engineer.

All costs in connection with furnishing, placing, shaping, and compacting the asphalt berm shall be included in the unit price per ton for "HMA class and grade being placed" and no additional compensation will be made.

5-04.3(24) CONSTRUCTED ROADWAY WIDTHS (NEW SECTION)

The Contractor is advised that in order to achieve the specified width of overlay on the streets as shown in the Plans, the overlay may need to be extended a foot or more beyond the existing pavement. Unless otherwise specified or as directed by the Engineer, all paved areas shall match existing paved areas including shoulders.

5-04.3(25) PULVERIZING (NEW SECTION)

Roadway Pulverization and Grading

Complete in-place Roadway Pulverization shall be done on the designated roads shown in the plans and as outlined in these Special Provisions.

The Contractor shall do the following to prepare the subgrade for surfacing.

1. Prior to pulverization, remove and dispose from the roadbed all brush, weeds, vegetation, grass, and other debris.
2. Drain water from all low spots or ruts.
3. The contractor shall pulverize the existing designated roadways to a minimum depth of six inches including asphalt surfacing and base materials. After pulverization, all material shall pass a 1-1/4-inch square sieve opening.
4. Shape the entire subgrade to a uniform surface running true to the line, grade, and cross section of the original roadway or as required by the Engineer. Every effort shall be made by the Contractor to shape the road with the pulverized material prior to the use of import.

Compaction equipment used in the test section shall be pneumatic tired rollers and/or vibratory equipment in the vibrating mode.

1. After each roller pass, a density reading is taken with the nuclear gauge at the test spot. Other locations within the test pattern area may also be tested at the discretion of the Engineer.
2. When the density readings increase by less than 1/2 pcf on any two consecutive passes, the rolling is discontinued and the rolling pattern is considered to be established.
3. Water shall be applied as required to control dust and aid during the compaction effort.
4. Each roadway shall be paved no more than 48 hours after pulverization.

5-04.5(1) QUALITY ASSURANCE PRICE ADJUSTMENT

This section and subsections 5-04.5(1)A and B are deleted in their entirety.

5-06 HOT MIX ASPHALT PG 64-22 (with 15 percent RAP and 3 percent (RAS)) (NEW SECTION)

5-06.1 DESCRIPTION

This Work shall consist of providing and placing one (1) or more layers of plant mixed hot mix asphalt (HMA) containing the required materials noted below in Section 5-06.2 on a prepared foundation or base in accordance with the lines, grades, thicknesses, and typical cross-sections shown in the Plans, Specifications, and in accordance with the specific requirements identified in the Special Provisions for HMA Section 5-04 (Except for 5-04.2 "Materials" which shall be as identified in 5-06.2 "Materials" below).

5-06.2 MATERIALS

The provisions of Section 5-04.2 Materials are applicable for this bid item with the exception of the following two items:

1. The third paragraph of Section 5-04.2 which is deleted in its entirety and replaced with the following:

The Contractor shall utilize RAP and RAS together in the production of HMA. The amount of RAP shall be 15 percent (plus or minus one-half of one percent) of the total weight of aggregate in the mix, and the amount of the RAS shall be 3 percent (plus or minus one-half of one percent) of the total weight of the aggregate in the mix. The RAP may be from pavement removed under the contract or pavement from an existing stockpile. The RAS material shall be in accordance with the material specifications articulated in Section 9-36 Recycled Asphalt Shingles (RAS) Specifications (New Section) of these Special Provisions.

2. And with the exception of the first sentence of the fourth paragraph of Section 5-04.2 of these Special Provisions which is deleted and replaced with the following:

   The grade of paving asphalt shall be PG 64-22.

7-05 MANHOLES, INLETS, CATCH BASINS, AND DRYWELLS

7-05.3(1) ADJUSTING MANHOLES AND CATCH BASINS TO GRADE

The following is added at the end of this section:

The Contractor shall adjust existing catch basin frames and grates to grade, where directed by the Engineer. Risers will be furnished by the County and available for pick up by the Contractor at the following locations:

King County's Maintenance Facility at Star Lake
26701 28th Avenue South
Kent, WA 98032

7.05.5 PAYMENT

The following is added at the end of this section:

All costs and expenses incurred to adjust catch basin frames and grates to grade shall be considered incidental to the various bid items in the contract and no further compensation will be made.

MISCELLANEOUS CONSTRUCTION

8-01 EROSION CONTROL AND WATER POLLUTION CONTROL

8-01.3(1) GENERAL

The following is added at the end of this section:

To protect the waters of the State, the use of diesel oil or other chemical products as a bond breaker between the asphalt material and drainage appurtenances, such as catch basins, manholes, grate inlets, etc., will no longer be allowed. The Contractor shall instead, utilize metal plates, plywood sheets, pre-approved inlet socks, etc., or other approved methods and devices, to prevent the introduction of all foreign matter, dirt, debris, grindings, asphalt materials including tack, other hazardous materials, etc., in the existing drainage system. The Contractor shall include in the TESC plan the methods he intends to use to comply with this section. No overlay work such as planing bituminous pavement, asphalt paving and placement of shoulder rock will be allowed on any road until approved devices are in place. If and when a failure occurs, and foreign matter enters the drainage system, the Contractor shall immediately stop all work and commence cleanup operations. Cleanup work shall be done to the satisfaction of the Engineer. Drainage structures that have to be paved over due to the lack of appropriate risers, as approved by the Engineer, shall be separated from the asphalt by use of a heavy-duty type construction paper. All costs and expenses for all work described in this section shall be considered incidental to

8-23.4 MEASUREMENT

This section is deleted in its entirety.

8-23.5 PAYMENT

This section is deleted in its entirety and replaced with the following:

All costs for providing, installing, removing, and disposing of temporary pavement markings shall be included in the price per ton for the applicable type of HMA placed (i.e. "HMA Cl. __ PG __").

9-36 RECYCLED ASPHALT SHINGLES (RAS) SPECIFICATIONS (NEW SECTION)

9-36.1 OVERVIEW

For purposes of this *SE 416th Street Overlay: Shingles in Paving Demonstration*, this specification requires that the Contractor ensure that the Shingle Recycling Operator and the Recycling Facility:

- Secure a supply of tear-off asphalt shingle scrap and stockpile it, process/grind the scrap, test and stockpile the RAS product;
- Be compliant with their jurisdictions comprehensive solid waste management plan, and any additional local solid waste handling regulations or requirements. For firms in Washington State this includes Chapter 173-350 WAC Solid Waste Handling Standards;
- For firms in Washington State, be permitted as a solid waste handling facility or has properly notified both the Department of Ecology and local health department of the intent to operate under the exemption option;
- Have the necessary plans in place for protecting worker health/safety and the environment;
- Perform testing on the finished RAS product and provide verification that the RAS product does not include asbestos containing material (ACM) as per local, state and federal regulations;
- Meet RAS material quality standards specified herein prescribed to help ensure optimum performance when used in hot mix asphalt (HMA); and
- Meet other stockpiling, sampling and testing requirements specified herein.

Material quality specifications and Shingle Recycling Operator and Recycling Facility qualifications are described in greater detail in the remainder of this Section 9-36. The Contractor is ultimately responsible for seeing that these specifications and qualifications are met by the Shingle Recycling Operator and Recycling Facility. All documentation, testing results, reports, and notifications that are generated as part of this Contract are to be transmitted from the Shingle Recycling Operator and its Recycling Facilities to the Contractor, and the Contractor will provide those to the Contracting Agency.

9-36.2 MATERIAL QUALITY SPECIFICATIONS

The Shingle Recycling Operator and Recycling Facility must meet the following sourcing, inspecting, processing, sampling, testing, and stockpiling standards, including those meant to ensure that the project is free of ACM.

1. **Requirements for Type of Raw Materials:** Only tear-off asphalt shingles are to be used for the project. Other asphalt roofing products (e.g., built up roofing, rolled or sheet roofing, etc.) shall not be used in this demonstration project.

2. **Requirements for Separation of Raw Materials:** Minor incidental amounts of other roofing materials (e.g., wood, plastic, metal, etc.) are allowed in the incoming loads to the Shingle Recycling Operator, but separation of these materials prior to grinding may be needed for the final product to be within limits of the amount and size of extraneous waste materials allowed in the final RAS product.

3. **Asbestos Testing Requirements**: Each incoming load of tear-off asphalt shingles for the demonstration project must be inspected by an Asbestos Hazard Emergency Response Act (AHERA)-accredited inspector at the time of unloading at the Shingle Recycling Operator's Recycling Facility. If suspect ACM material is found in incoming loads, the load **shall** be rejected or tested for ACM. If material is determined to contain ACM, then the Shingle Recycling Operator must notify the Contractor and follow the rules of Puget Sound Clean Air Agency for handling asbestos and this material **shall not** be used in the demonstration project. The Contractor will notify the Contracting Agency under these circumstances.

4. **Sampling Requirements**: The finished RAS material to be incorporated into the HMA paving demonstration must be randomly sampled in accordance 9-36.4 RAS Sampling and Testing Requirements and tested to ensure that it is free of ACM according to procedures specified in these RAS Specifications.

5. **Gradation Requirements:** The final RAS product shall be processed so that 100 percent passes the 12.5-mm (1/2 inch) sieve and a minimum of 95 percent passes the 9.5-mm (3/8 inch) sieve when tested in accordance with the test method in Washington State Department of Transportation's (WSDOT) *Materials Manual* "FOP for WAQTC/AASHTO for Sieve Analysis of Fine and Coarse Aggregates." (See Appendix 3)

6. **Requirements Regarding Extraneous Waste Materials:** The final RAS product to be used in the HMA shall be substantially free of extraneous waste materials and entirely free of whole, intact nails. Lighter extraneous material such as paper, wood and plastic shall not exceed 1.5 percent by mass as determined on material retained on the 4.75-mm (No. 4) sieve. Total extraneous materials including metals, glass, rubber, nails, soil, brick, tars, paper, wood and plastic shall not exceed 3.0 percent by mass as determined on material retained on the 4.75-mm (No. 4) sieve. The method of sampling and testing shall be in accordance with "FOP for AASHTO Standard Practice for Sampling Aggregates" and "FOP for WAQTC/AASHTO Sieve Analysis of Fine and Coarse Aggregates." (See Appendix 3.)

7. **RAS Moisture Content:** The final RAS product to be used in the HMA shall not contain more than 5.0 percent moisture when tested in accordance with "FOP for AASHTO Total Evaporable Moisture Content of Aggregate by Drying." (See Appendix 3) The Shingle Recycling Operator shall take necessary steps to ensure excessive moisture is not retained in the RAS stockpiles.

9-36.3 SHINGLE RECYCLING OPERATOR AND RECYCLING FACILITY QUALIFICATIONS

In addition to producing a RAS product that meets the material quality specifications outlined above, the Shingle Recycling Operator shall certify that it and its Recycling Facility meet all relevant safety, health and environmental regulations and standards, including, but not limited to, the following requirements:

1. Be compliant with their jurisdiction's comprehensive solid waste management plan and any additional local solid waste handling regulations or requirements. For firms located in Washington State, this includes Chapter 173-350 WAC Solid Waste Handling Standards;

2. For firms located in Washington State, be permitted as a solid waste handling facility or has properly notified both the Department of Ecology and local health department of the intent to operate under the exemption option;

3. Have in place a workplace accident prevention program that addresses workplace hazards in accordance with local and state regulations. For firms located in Washington State, this includes WAC 296-800-140. The plan must address asbestos hazards; and

4. The Contractor must submit a form, completed and signed by the Shingle Recycling Operator, that certifies that the Shingle Recycling Operator and its Recycling Facility meet the above requirements and standards. (See Appendix 2 RAS Supply Verification Form.)

9-36.4 RAS SAMPLING AND TESTING REQUIREMENTS

The Shingle Recycling Operator shall collect and test samples of the finished RAS product to be utilized in the demonstration project. The Shingle Recycling Operator shall document sampling methods and maintain adequate records of all testing results. Copies of all test records shall be submitted to the Contracting Agency no later than the next business day after the test.

The Shingle Recycling Operator shall use standard procedures for RAS product sampling from the stockpile as per "FOP for AASHTO Standard Practice for Sampling Aggregates." (See Appendix 3) [Note: Alternative or additional sampling collection procedures may be proposed by the Shingle Recycling Operator subject to the prior approval by the Contracting Agency and KCSWD.]

9-36.4(A) ASBESTOS TESTING

The Contractor and Shingle Recycling Operator shall be responsible for providing the following:

1. Asbestos testing shall occur on the finished RAS product after grinding, screening or other finishing processes are complete. For purposes of asbestos testing, the Shingle Recycling Operator shall collect a random one (1) pound sample from the finished RAS product stockpile for every ten (10) tons of RAS produced.

2. Each of the one (1) pound samples shall be divided in half and each half clearly labeled (Example: "Sample #1A" and "Sample #1B", "Sample #2A" and "Sample #2B", etc.). The samples labeled with an "A" shall be transmitted to an accredited asbestos testing laboratory. The samples labeled with a "B" shall be retained, stored for 90 days, and made available to the Contracting Agency upon request.

3. The samples send to the accredited asbestos testing laboratory shall be analyzed by polarized light microscopy as specified in EPA regulations 40 CFR Part 763, Subpart E by an accredited independent laboratory.

4. The Shingle Recycling Operator shall provide the Contractor copies of all original asbestos laboratory reports for submittal to the Contracting Agency.

5. The Shingle Recycling Operator shall allow the Contracting Agency, KCSWD and WSDOT safe access to its Recycling Facility to observe the shingles recycling operations.

6. The Shingle Recycling Operator shall allow the Contracting Agency, KCSWD and WSDOT to arrange and provide safe access to the stockpile for a separate collection of samples directly from the finished RAS product pile upon request.

7. If ACM is found in the RAS product stockpile, the Contractor and Contracting Agency must be notified within 2 hours, and the entire stockpile shall not be used for the project and shall be disposed of in accordance with applicable legal requirements governing such disposal at the Shingle Recycling Operator's expense.

9-36.4(B) CONSTRUCTION MATERIAL QUALITY CONTROL AND VERIFICATION TESTING

Quality control and verification testing should be conducted on the finished RAS product after screening or other finishing processes are complete. Testing should be completed using the following procedures.

1. The Shingle Recycling Operator shall collect six (6) random material samples of the finished RAS product. Three (3) of these samples shall be retained for 90 days by the Shingle Recycling Operator and three (3) of these samples shall be shipped in accordance with the Contracting Agency's submittal instructions (Contact Agency Representative).

2. Each sample shall be a minimum of 25 pounds.

3. The Shingle Recycling Operator must test the samples for compliance with the "Material Quality Specifications" as specified herein (Section 9-36.2.)

4. All test results, including copies of original lab reports, must be provided to the Contractor and the Contracting Agency.

9-36.5 SOLID WASTE REGULATION COMPLIANCE

Recycled Asphalt Shingles (RAS) are at this time a regulated solid waste. The agencies that enforce these regulations within counties are the jurisdictional health departments and the Washington State Department of Ecology. The Code of the King County Board of Health Title 10 is the regulation that applies to solid waste management in King County. Title 10 has adopted by reference the Washington Administrative Code (WAC) 173-350 solid waste regulations. In Pierce County, the applicable solid waste management code is Chapter 28 Solid Waste Handling Standards of the Tacoma-Pierce County Board of Health. The Snohomish Health District Sanitary Code Chapter 3.2, WAC 173-350 solid waste handling standards are the regulations that govern solid waste handling, storage, collection, processing, treatment, transportation and final disposal within Snohomish County.

The Contractor shall adhere to the Contract schedule requirements as identified in Section 1-08.3, which stipulates a limited contract time frame in which to complete the required work.. Because that contract time frame is less than three (3) months the Contractor will not be subject to the requirements in WAC 173-350-320 Piles used for storage or treatment. Therefore the Contractor is not required to obtain a solid waste handling permit or to submit a permit exemption notification. However, if the Contractor fails to keep the Contract schedule requirements, and stores the RAS pile or any remaining RAS materials at its facility for longer than three (3) months, then other regulatory sections of the WAC 173-350-320 piles standard section may apply to the Contractor storage of the RAS material. Compliance with all solid waste regulations shall be the sole responsibility of the Contractor.

Since RAS is a solid waste the Contractor is required to reduce risk to human health and the environment by complying with the Washington state solid waste regulations WAC 173-350-040 Performance standards (see below).

WAC 173-350-040 Performance standards.
"The owner or operator of all solid waste facilities subject to this chapter shall:

(1) Design, construct, operate, and close all facilities in a manner that does not pose a threat to human health or the environment;

(2) Comply with chapter 90.48 RCW, Water pollution control and implementing regulations, including chapter 173-200 WAC, Water quality standards for ground waters of the state of Washington;
(3) Conform to the approved local comprehensive solid waste management plan prepared in accordance with chapter 70.95 RCW, Solid waste management – Reduction and recycling, and/or the local hazardous waste management plan prepared in accordance with chapter 70.105 RCW, Hazardous waste management;
(4) Not cause any violation of emission standards or ambient air quality standards at the property boundary of any facility and comply with chapter 70.94 RCW, Washington Clean Air Act; and
(5) Comply with all other applicable local, state, and federal laws and regulations."

Though the Contractor is solely responsible for complying with WAC 173-350-040 Performance standards, representatives of the King County Department of Transportation and the jurisdictional health department will be available, including site visits, to provide information and suggestions on how the Contractor can achieve compliance. An initial site visit will be offered to the Contractor to assess the site and discuss RAS material storage methods/practices for successful Performance Standards compliance, before RAS is accepted at the facility.

The Contractor may elect to use the methods/practices listed below or other methods/practices at their discretion, as long as it is in compliance with the above referenced solid waste regulations. The primary exposures that are of concern are to ground and surface water, and air quality.

Stormwater
To eliminate stormwater run-on and run-off, the RAS pile may be stored 1) inside a building, 2) on a concrete pad that drains to the sewer, 3) under a tarp in an area where surface water cannot flow through the base of the pile, or 4) in some other manner that is protective of ground and surface water standards.

Fugitive Dust
To eliminate fugitive dust, the RAS pile may be 1) covered with a tarp, or 2) use some other method that is protective of air quality standards.

The contractor shall permit access by the jurisdictional health department representative and the representative of the Washington State Department of Ecology to inspect the shingle piles for the purpose of determining compliance with WAC 173-350-040 Performance standards. Inspections may be conducted by the jurisdictional health district at random times at a minimum of once every month during the time the RAS is at the Contractor's facility. It is not anticipated that more frequent inspections will be conducted unless the Performance Standards are not being met. The goal of inspections is to assist the Contractor in meeting the Performance Standards. When the RAS material is received by the Contractor, the jurisdiction health department will be notified to schedule the first inspection.

King County

APPENDIX 1

BIDDER'S RESPONSIBILITY FORMS

- BIDDER'S RESPONSIBILITY FORM
- TABLE 1A

Appendix 1: Bidders Responsibility Form

SECTION A. The Bidder shall demonstrate that its team possesses the following required elements of responsibility:	
Element #	**Description**
1	**Own and operate the HMA plant proposed for use on this project.** **RESPONSE:** Physical address of Proposed HMA Plant:
2	**The ability and capacity of the HMA plant proposed for use on this project to precisely control (a) the relative ratio of the RAP percentage by weight and (b) the relative ratio of the RAS percentage by weight, as these two materials are incorporated into the two HMA mixes.** **RESPONSE:** Describe what equipment proposed plant uses that provides the HMA Plant Operator with the ability and capacity to precisely control: **(a)** the relative ratio of the RAP percentage by weight **(b)** the relative ratio of the RAS percentage by weight,
3	**Successfully paved a minimum of 10,000 tons of HMA on public roadway projects (either new construction or maintenance overlay), incorporating a minimum of 1000 tons of RAP in the HMA mix, within the last two years.** **RESPONSE:** Complete Item # 1 in the attached Table 1A.

4	**A minimum of six (6) months of experience researching, experimenting, testing, producing, and evaluating each of the following: (a) RAS Material; (b) RAS incorporated into HMA mix for paving.**
	RESPONSE: Please itemize and attach example reports of plans and results describing strategies for incorporating RAS into HMA. Please document your six (6) months of experience on each of the following: (a) RAS Material (b) RAS incorporated into HMA mix.
5	**Successfully completed one (1) or more paving projects with a combined total of at least 500 tons of HMA mix that includes the controlled use of RAP and RAS. The HMA need not have been produced at the HMA plant proposed for this project.**
	RESPONSE: Complete Item # 2 in the attached Table 1A.
6	**An accredited Asbestos Hazard Emergency Response Act (AHERA) inspector on staff or under contract to inspect for ACM in incoming loads of tear-off asphalt shingle scrap to be used to produce the final RAS product for this project.**
	RESPONSE: Provide copy of proposed AHERA inspector's accreditation.
7	**Have the necessary capacity to: (1) receive and store new tear-off asphalt shingle scrap; (2) process the scrap, and; (3) store it in a separate stockpile from other materials.**
	RESPONSE: Provide a one to three paragraph description of this capacity of proposed plans for this work.
8	**Ability to meet the time limits identified in the Contract.**
	RESPONSE: Provide preliminary schedule of tasks.

SECTION B. Bidder shall also demonstrate or provide the following:	
Element #	**Description**
1	**How it shall self perform work equivalent to at least 70 percent of the Contract Price.**
	RESPONSE: The Bidder shall demonstrate this by identifying the work using the specification divisions or sections within a division it intends to perform with its own forces and the estimated dollar amount and percentage to its overall bid amount this itemized work constitutes
2	**A brief description of the applicable work experience with the elements identified in Section A above for the following key project team members :** i. Project Manager ii. Project Superintendent, if different than the Project Manager iii. Designated HMA Plant Operator iv. Designated Asphalt Shingle Recycling Facility Operator v. AHERA Accredited Inspector vi. Road Paving Lead The above project team members shall be considered Key Personnel and shall actively participate in the project for the duration of the project unless replaced with another person with similar experience. Such replacements shall be approved by the Engineer.
	RESPONSE: Attach brief descriptions as required for Key Personnel
3	**Provide a preliminary project schedule which demonstrates the Bidder's management and understanding of the Contract Work. Provide a schedule in sufficient detail to demonstrate how the Bidder expects to comply with the Contract Milestones and the Substantial Completion date. Include at least the following:** a) Activities identified as part of Phase I Preconstruction Activities and Materials Testing_found in Section 1-09.8 of these Special Provisions. b) Activities identified as part of Phase II Construction Paving found in Section 1-08.3 of these Special Provisions. c) Substantial Completion. d) Physical Completion
	RESPONSE: Provide preliminary schedule as noted above.

4	**Provide the following environmental compliance documentation from the Shingle Recycling Operator for the Asphalt Shingle Recycling Facility proposed for use on this Contract: Either of the following:** a) Solid Waste Handling Permit Number and a copy of the section of the Plan of Operation, approved by the local health jurisdiction, that describes asphalt shingle processing; **or** b) Copies of the Recycling or Material Recovery Facility Notice of Intent to Operate under Terms and Conditions for Solid Waste Permit Exemption and the corresponding approval letter from the local health jurisdiction for the Solid Waste Permit Exemption.
	RESPONSE: Provide either (a) or (b) as noted above.
5	**The Bidder shall provide a copy of any official documentation which reflects any written warnings or violations of any local, state, or federal environmental or solid waste laws or regulations within June 2008 to the present.** The County will evaluate to determine if the Bidder's contract history demonstrates quality of past performance and the capability to successfully manage and construct this Project. a) Identify if within the past 5 years that the Bidder or, if the Bidder is a JV or BOS, any member of the JV or BOS has: b) Had a contract terminated for cause or default; c) Has been (a) convicted of a willful violation or (b) issued a willful violation citation by Department of Labor & Industries, or similar organization with jurisdiction in the United States; d) Not been an active contractor; e) Been in bankruptcy, reorganization and/or receivership; f) Not been registered and licensed as a construction contractor; g) Been disqualified by any federal, state or local agency from being awarded and/or participating in public contracts. h) Explain the circumstances surrounding the event identified above.
	RESPONSE: Provide requested information and documentation noted above.
6	**The County will evaluate to determine if the Bidder's criminal history demonstrates inappropriate character, integrity, reputation, judgment, and experience of the Bidder. Identify all criminal convictions, including pleas of nolo contendere, of the Bidder and any officers of the Bidder. If the Bidder is a JV or BOS, provide all information for each member of the JV or BOS.**
	RESPONSE: Provide written response.

7	**Submit the Bidder's accident/injury experience factor from the Department of Labor and Industries or other appropriate organization from the year 2005 to present. If the Bidder is a joint venture, provide information for members of the joint venture who will be performing and managing the Contract work. If a JV or BOS partner is only providing financial support, this information is not required and will not be evaluated with regard to this element.**
	RESPONSE: Provide written response.
8	**At the County's request, provide any additional explanation or information, which would assist in evaluating the qualifications of the Bidder, subcontractors, project team members, JV or BOS members, and bid price.**
	RESPONSE:

TABLE 1A

1. Use of RAP in HMA

Please provide information on completed road construction projects utilizing RAP in HMA from the HMA plant proposed to supply the asphalt under this Contract. The projects listed should total at least 10,000 tons of HMA. Attach duplicate sheets if necessary.

Project Date	Project Name and Location	Project Owner, Contact Name, and Phone Number	HMA Plant Name/Location	Tons of HMA Used	% of RAP in HMA
			Total Tons		

TABLE 1A

2. Completed paving project and/or test sections incorporating RAS and RAP

Please provide information on completed road construction projects or test sections utilizing RAP and RAS in HMA. The projects listed should total at least 500 tons of HMA. The RAS/RAP HMA need not have been produced at the HMA plant proposed for this project.

Project Date	Project Name and Location	Project Owner, Contact Name, and Phone Number	HMA Plant Name/Location	Tons of HMA Used	% of RAS in HMA	% of RAP in HMA
			Total Tons			

King County

APPENDIX 2

- RAS SUPPLYVERIFICATION FORM

Appendix 2: RAS Supply Verification Form

The Shingle Recycling Operator and Recycling Facility proposed to supply RAS material for the *SE 416th Street Overlay: Shingles in Paving Demonstration* must complete the information below. King County understands that the Shingle Recycling Operator may be the Bidder or a separate company contracted by the Bidder. The selected Bidder shall submit this form to King County within three (3) working days after Notice to Proceed.

Shingle Recycling Operator

Company name:_____

Address:_____

Web Site: _____

Recycling Facility Address (if different than Company Address):

_____

Contact Name:_____

Phone number: _____

Email:_____

CERTIFICATION

We the undersigned will meet and adhere to the RAS Specifications outlined in Section 9-36 of this Contract. In addition, we certify the following:

- ☐ We currently have the equipment and operations in place to meet the RAS Specifications for the required quantities.
- ☐ We agree to openly communicate about the production of the final RAS product and the final HMA mix and to respond specific requests from the King County Contract Manager.
- ☐ We agree to let Project Team members sample and test the RAS product as necessary during the production process.
- ☐ We agree to provide information, and allow King County to take photographs and video to enable King County to document the demonstration project. Information may include (but is not limited to) costs challenges, benefits, or overall experience producing the product to specification. Information, images and video are subject to item 4 under IMPORTANT NOTES REGARDING THIS PROJECT in GENERAL REQUIREMENTS of this Invitation to Bid.

Print Name _____ **Title**_____

Signature _____ **Date** _____

King County

APPENDIX 3

- SELECTED TEST METHODS FROM WSDOT'S MATERIALS MANUAL

Appendix 3: Selected Test Methods from WSDOT's Materials Manual

Attached is a summary of relevant test methods from WSDOT's Materials Manual (January 2009), which reflects the continual policy of adopting consensus standards across AASHTO, ASTM, WAQTC, and WSDOT test methods wherever possible.[1]

The full Materials Manual can be accessed online at http://www.wsdot.wa.gov/publications/manuals/fulltext/M46-01/Materials.pdf as described on the WSDOT web page: http://www.wsdot.wa.gov/Publications/Manuals/M46-01.htm

King County Solid Waste Division LinkUp team members, working with WSDOT, will provide informational technical assistance on these procedures to the Shingle Recycling Operator proposed to supply the RAS materials for this project.

Procedure	Number	Owner	Test Method (January 2009)
T	27/11	WSDOT	FOP for WAQTC/AASHTO for Sieve Analysis of Fine and Coarse Aggregates
T	308	WSDOT	FOP for AASHTO for Determining the Asphalt Binder Content of Hot Mix Asphalt (HMA) by the Ignition Method
T	2	WSDOT	FOP for AASHTO for Standard Practice for Sampling Aggregates
T	255	WSDOT	FOP for AASHTO for Total Evaporable Moisture Content of Aggregate by Drying

1 WSDOT annually publishes an updated version of its Materials Manual every January.

King County

APPENDIX 4

- SUMMARY OF REQUIRED RAS SAMPLES AND TESTS BY CONTRACTOR

Appendix 4: Summary of Required RAS Samples and Tests by Contractor

The following RAS samples and tests shall be performed by the Contractor in accordance with the RAS Specifications outlined in Section 9-36 of this Contract. (a)

Schedule	King County ID # (b)	Test or Survey Item	Contractor Responsibilities
Early July		**Contractor's Report and Preliminary RAS Processing**	
	8	KCDOT and WSDOT to verify RAS and RAP measuring or metering process used by Contractor.	Contractor to submit process report after pre-construction conference.
Early July		**Contractor Develops Traditional Virgin HMA Mix Design**	
	9	Traditional HMA mix design	Contractor to develop traditional virgin HMA mix design and submit representative samples of aggregates to WSDOT for verification.
Mid July		**Final Grind and Preliminary RAS Sampling**	
	10 - 14	RAS samples	Contractor collects duplicate RAS samples and submits one set to WSDOT as per RAS specification.
	10	RAS gradation	Contractor to sample, test, and report results to KCDOT.
	12	RAS moisture	Contractor to sample, test, and report results to KCDOT.
	13	RAS extraneous waste materials content	Contractor to sample, test, and report results to KCDOT.
	14	RAS asbestos	Contractor to sample, test with independent lab, and report results to KCDOT (as per RAS specification).
	26	WSDOT develops RAS + RAP mix design.	Contractor to submit RAP samples to WSDOT. Contractor may need to respond to WSDOT's mix design recommendations for the RAS + RAP test mix.

Notes:

(a) Most of the samples and tests above relate to the addition of RAS and RAP to HMA. They are in addition to the normal materials testing requirements per the Project specifications and referenced WSDOT requirements, including QA/QC tests on the virgin HMA.

(b) Test ID # sequence per King County's internal testing work plan. Contractor not responsible for omitted numbered tests (not shown in this Appendix).

King County

APPENDIX 5

- PROCESS REPORT OUTLINE

PROCESS REPORT OUTLINE

The Contractor shall provide a Process Report for using RAP and RAS in HMA. The Report will including any supplemental materials such as diagrams or photographs, showing the experience, equipment and methods that will be used to process RAS, and mix, place and compact HMA containing RAS and RAP as required by this Contract. The Process Report shall be submitted by the selected Bidder within three (3) working days after Notice to Proceed, and it must include the following elements:

- Proposed Shingle Recycling Operator.
- Past relationship with the RAS Supplier.
- Source(s) of tear-off asphalt shingle scrap the RAS Supplier will use (e.g., roofing companies, haulers, etc.).
- Inspection by AHERA Accredited inspector, as tear-off asphalt shingle scrap is received at the Recycling Facility
- Description of how the extraneous waste materials will be separated to ensure they are not incorporated into the RAS at a rate that exceeds the RAS Specifications limit.
- Identification of the equipment and processes to be used in processing tear-off asphalt shingles into RAS in sufficient quantities to meet the needs of the project.
- Description of how the RAS material will be stored.
- Description of any RAS and RAP material blending.
- Description of how the RAS and RAP material will be introduced into the HMA mix to ensure that all materials have not clumped or aggregated to any extent.
- Description of how the RAS material will be metered to control a precise percentage into the HMA mix.
- Description of how the RAP material will be metered to control a precise percentage into the HMA mix.
- Summary of safety plans in place for adequately protecting workers handling both RAS and HMA.
- Any other pertinent descriptions of the process of using RAS and RAP in HMA.

Mark any and all pages of the Process Report the selected Bidder considers proprietary or confidential. The Process Report is subject to item 4 under IMPORTANT NOTES REGARDING THIS PROJECT in GENERAL REQUIREMENTS of this Invitation to Bid.

King County

Department of Transportation
Road Services Division
Construction Engineering Unit
201 S Jackson Street
Seattle, WA 98104-3856

Contractors Submittals

Submit At or Prior To the Pre-Construction Conference

The Contractor, as specified in the Special Provisions, shall submit the following submittals on or before the Pre-Construction Conference:

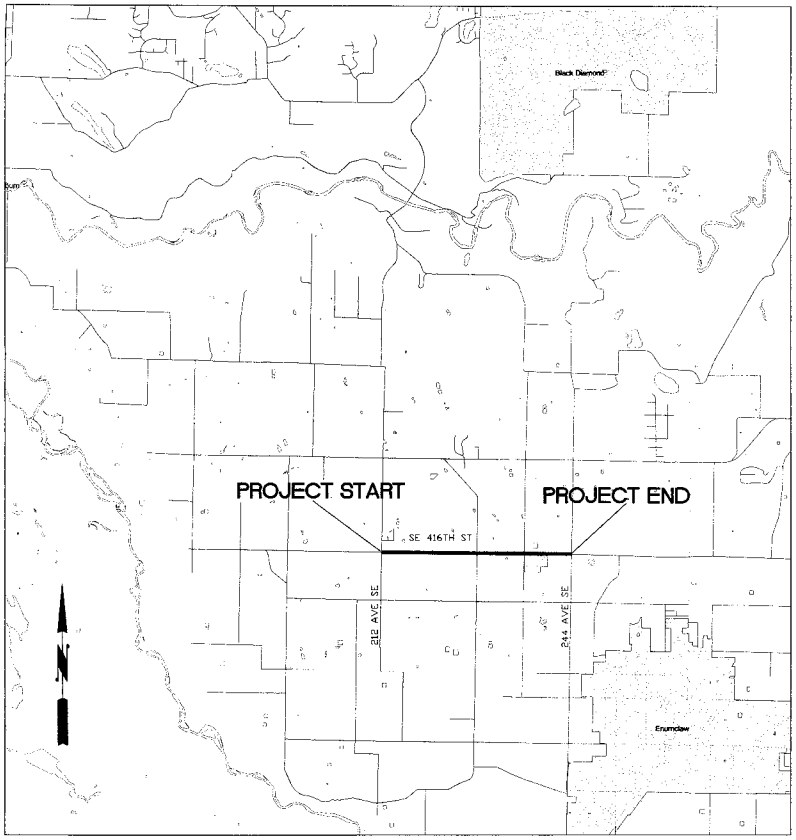
- ❑ Process Report (Section 1-09.8)
- ❑ RAS Samples (Appendix 4)
- ❑ RAS Supply Verification Form, Samples, Test Results (Section 9-36)
- ❑ Site Safety Program & Subcontractor's Safety Program (Section 1-05.8)
- ❑ Site Safety & Health Officer's 40 hour OSHA Hazmat Certificate (Section 1-05.8(1))
- ❑ Emergency Contacts (Section 1-05.13(1))
- ❑ Collection, Containment, and Disposal Plan (Section 1-07.5(6))
- ❑ Spill Prevention, Control and Countermeasures Plan (Section 1-07.15(1))
- ❑ Progress Schedule (Section 1-08.3(2)A)
- ❑ Traffic Control Plan (Section 1-10.2(2))
- ❑ Temporary Erosion and Sediment Control Plan (Section 8-01.3(1)A)
- ❑ Roadside Work Plan (Section 8-02.3(2))
- ❑ Fugitive Dust Control Plan (Section 8-31.1)
- ❑ Erosion and Sediment Control Lead Certificate (Section 8-01.3(1)B)

Contractor Submittals Prior To, During or Following Commencement of Work

The Contractor, as specified in the Special Provisions, shall submit the following submittals as required prior to, during or following commencement of the project work:

- ❑ Request for Approval of Subcontractors and Agents (Section 1-08.1)
- ❑ Statement of Intent to Pay Prevailing Wages (Section 1-07.9(5))
- ❑ Certified Weekly Payrolls (Section 1-07.9(5))
- ❑ Materials Certifications and Invoices (Section 1-06.3)
- ❑ Record Drawings (Section 1-05.5)
- ❑ Requests for Approval of Materials Sources (Section 1-06.1(2))
- ❑ Materials Samples (Section 1-06.2(1))
- ❑ Haul and Disposal Records (Section 2-03.3(7)C)
- ❑ Affidavit of Amounts Paid (Section 1-07.9(5)A)
- ❑ Traffic Control Manager and Traffic Control Supervisor Certificates (Section 1-10.2(1))
- ❑ Flagging Certificates (Section 1-10.3(1)A)
- ❑ Delivery Tickets for Weighed Materials signed by Licensed Weighmaster (Sec. 1-09.2)

Other submittals may be required to supplement the above noted lists as required by the Engineer, the Contract Documents, and/or other regulatory agencies



VICINITY MAP
NOT TO SCALE

1 COVER SHEET
2 ROAD SECTIONS/DETAILS
3 OVERLAY PLAN – ENUMCLAW AREA

King County

Department Of Transportation Road Services Division

HAROLD TANIGUCHI
DIRECTOR

SUMMARY OF QUANTITIES

PROJECT LIMITS: SE 416TH ST FROM 212TH AVE SE TO 244TH AVE SE
LENGTH: 2.02 TOTAL MILES

ITEM NO.	TOTAL QUANTITY	UNIT	STD. ITEM NO.	ITEM	PROJECT NUMBER KING COUNTY M78030	AS BUILT
				PREPARATION		
1	LUMP SUM	L.S.		Removing Plastic Traffic Markings, Rumble Strips, and Raised Pavement Markers	1.0	
				SURFACING		
2	560	TON	5120	Crushed Surfacing Top Course	560	
				HOT MIX ASPHALT		
3	680	S.Y.	5711	Planing Bituminous Pavement	680	
4	2,100	TON		HMA Cl. 1/2" PG 64-22 With 15% RAP	2,100	
5	1,900	TON		HMA Cl. 1/2" PG 64-22 With 15% RAP and 3% RAS	1,900	
				EROSION CONTROL AND LANDSCAPING		
6	2,000	EST.	6490	Erosion / Water Pollution Control	2,000	
				OTHER ITEMS		
7	10,000	EST	7728	Minor Changes	10,000	
8	LUMP SUM	L.S.	7736	SPCC Plan	1.0	
9	LUMP SUM	L.S.		Preconstruction Activities and Materials Testing	1.0	

APPROVED FOR CONSTRUCTION

4/8/09
MATTHEW NOLAN, P.E.
ACTING COUNTY ROAD ENGINEER

CALL 2 WORKING DAYS BEFORE YOU DIG
1-800-424-5555
(UNDERGROUND UTILITY LOCATIONS ARE APPROX.)

FIELD BOOK:				
SURVEYED:				
SURVEY BASE MAP:				
DESIGN ENTERED:	K. DERR	6/2009		
DESIGNED	P. MOORE	6/2009		
CHECKED:	F. OVERTON	6/2009		
SUPERVISOR:	J. EAGAN	6/2009		

NUM.	REVISION	BY	DATE

FED. AID No.
PROJECT No. M78030
SURVEY No.
MAINTENANCE DIVISION No. 4

JAMES P. EAGAN — STATE OF WASHINGTON — 28028 — REGISTERED PROFESSIONAL ENGINEER

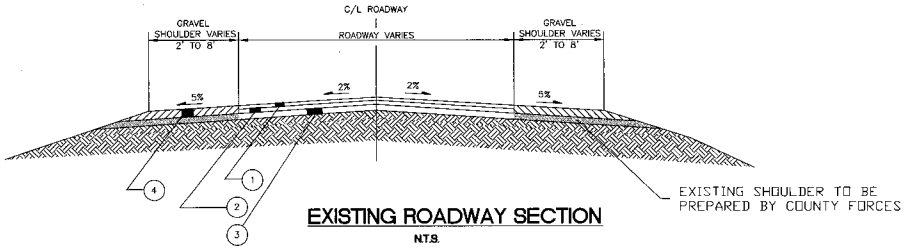
KING COUNTY DEPT. OF TRANSPORTATION
HAROLD TANIGUCHI, DIRECTOR
SE 416TH STREET OVERLAY
SHINGLES in PAVING DEMONSTRATION

King County

SHEET 1 OF 3 SHEETS

317-32

215



EXISTING ROADWAY SECTION
N.T.S.

SURFACE MATERIALS FOR ALL WORK

1. HMA CL 1/2" FOR TYPE OF MATERIAL (EITHER HMA w/RAS and RAP OR HMA w/RAP ONLY) DEPTH, AND CLASS SEE TABLE SHEET 3
2. 3/4" AVERAGE DEPTH PRELEVEL (AS DIRECTED BY ENGINEER)
3. EXISTING ROADWAY
4. CRUSHED SURFACING TOP COURSE

NOTES:

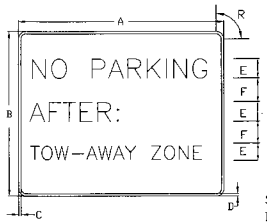
EXISTING ROADWAYS AND SHOULDERS SHALL BE OVERLAYED TO MATCH EXISTING WIDTHS UNLESS OTHERWISE DIRECTED BY THE ENGINEER.

SHOULDER PREPARATION TO BE PERFORMED BY COUNTY FORCES.

PLANING WIDTH AND DEPTH SHALL BE PER PLAN UNLESS OTHERWISE DIRECTED BY THE ENGINEER.

APPLICABLE TYPICAL SHOULDER SECTION SHALL BE DETERMINED BY THE ENGINEER.

TYPICAL SHOULDER SECTIONS
N.T.S.



DIMENSIONS (INCHES)

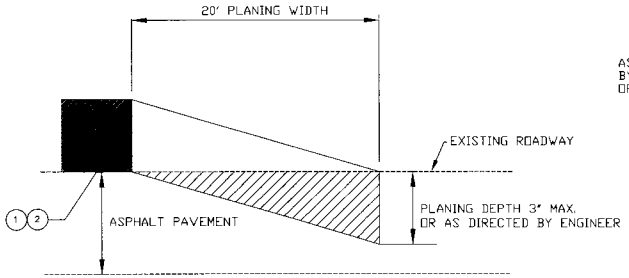
SIGN	A	B	C	D	E	F	R	HOLE CTRS
MIN.	24	18	3/8	5/8	30	20	1.5	
SPEC.	30	24	3/8	5/8	40	30	1.5	

COLORS

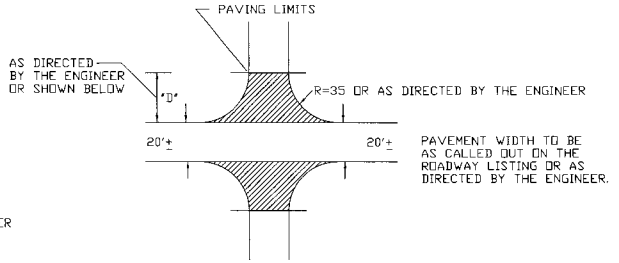
SIGN: RED REFLECTIVE
BACKGROUND: WHITE REFLECTIVE
MOUNTING: TYPE II BARRICADE

SIGN DETAIL
N.T.S.

NOTE: SIGNS SHALL BE PLACED 5 DAYS BEFORE PAVING.



TRANSVERSE JOINT PLANING
N.T.S.



TYPICAL INTERSECTION
N.T.S.

CALL 2 WORKING DAYS BEFORE YOU DIG
1-800-424-5555
(UNDERGROUND UTILITY LOCATIONS ARE APPROX.)

FIELD BOOK:					
SURVEYED:					
SURVEY BASE MAP:					
DESIGN ENTERED:	K. DERR	6/2009			
DESIGNED	P. MOORE	6/2009			
CHECKED:	F. OVERTON	6/2009			
SUPERVISOR:	J. EAGAN	6/2009	NUM.	REVISION	BY / DATE

FED. AID No.
PROJECT No. M78030
SURVEY No.
MAINTENANCE DIVISION No.

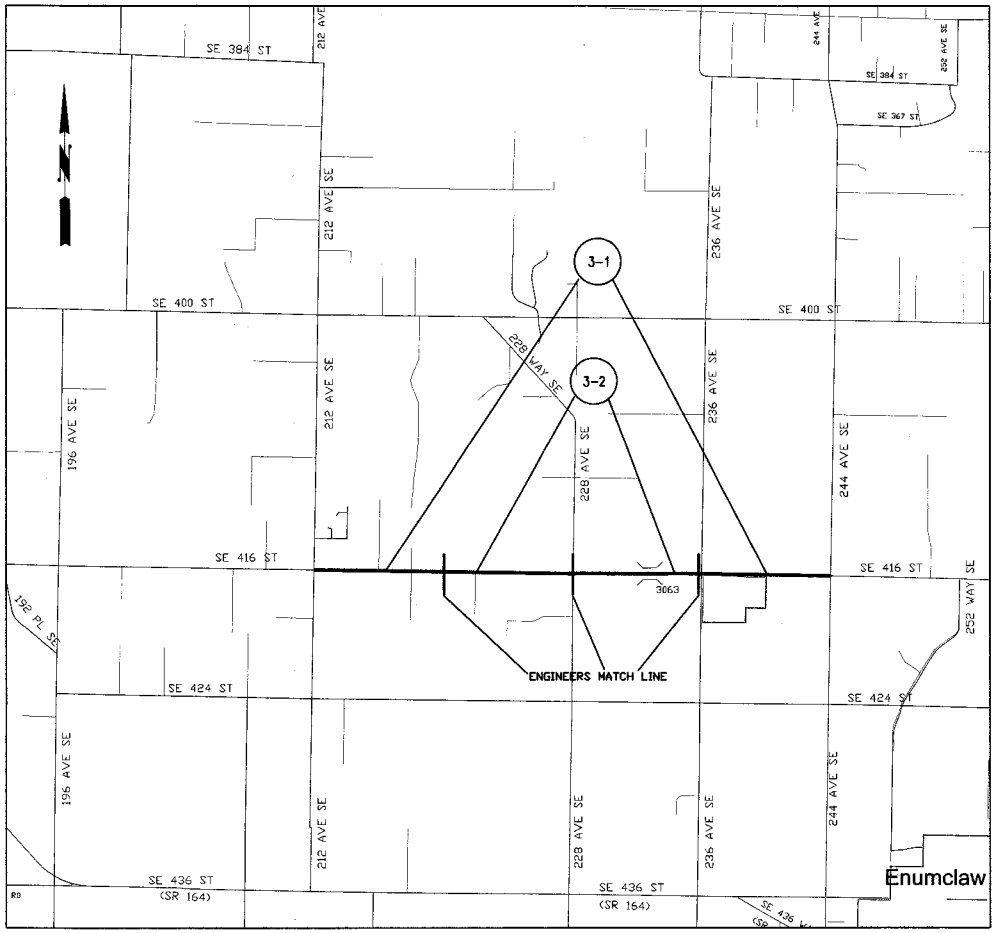
JAMES J. EAGAN — STATE OF WASHINGTON — 29000 — REGISTERED PROFESSIONAL ENGINEER

KING COUNTY DEPT. OF TRANSPORTATION
HAROLD TANIGUCHI, DIRECTOR
SE 416TH STREET
SHINGLES in PAVING DEMONSTRATION
ROAD SECTION / DETAILS SHEET

King County

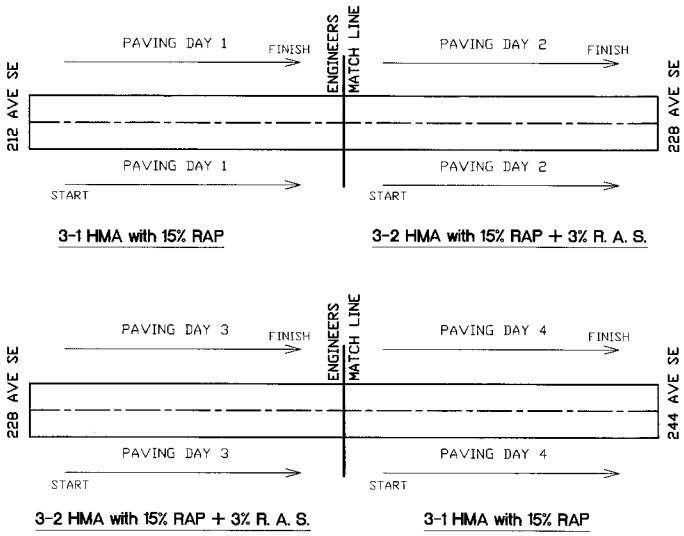
SHEET 2 OF 3 SHEETS

317-32



QUANTITY TABULATION AND LOCATION FOR HMA CL. 1/2"									FINAL QUANTITY			
MAINTENANCE DIVISION 4												
LOCATION CODE	DESCRIPTION	WIDTH	MILES	HMA w/ RAP TONS	HMA w/ RAS and RAP TONS	CSTC TONS	PLANING SY	DEPTH INCHES	HMA w/ RAP TONS	HMA w/ RAS and RAP	CSTC TONS	PLANING SY
3-1	KING COUNTY - PROJECT # M78030 SE 416TH ST	27	1.01	1,900	0	280	180	2.00				
3-2	SE 416TH ST	27	1.01	0	1,900	280	500	2.00				
	PRELEVEL AS DIRECTED BY ENGINEER FROM 212TH AVE SE TO 244TH AVE SE	27	-	200	0	0	0	VARIES				
			2.02	2,100	1,900	560	680					

NOTES: PLANE BRIDGE APPROACHES. DO NOT PAVE BRIDGE UNLESS DIRECTED BY ENGINEER.
PLEASE SEE SPECIAL PROVISIONS FOR THE SPECIFICATIONS ON THE "SE 416th ST RAS TEST SECTION".



PAVING TYPE / SCHEDULE

CALL 2 WORKING DAYS BEFORE YOU DIG 1-800-424-5555 (UNDERGROUND UTILITY LOCATIONS ARE APPROX.)

FIELD BOOK:		
SURVEYED:		
SURVEY BASE MAP:		
DESIGN ENTERED:	K. DERR	6/2009
DESIGNED	P. MOORE	6/2009
CHECKED:	F. OVERTON	6/2009
SUPERVISOR:	J. EAGAN	6/2009

NUM.	REVISION	BY	DATE

FED. AID No.
PROJECT No. M78030
SURVEY No.
MAINTENANCE DIVISION No. 4

KING COUNTY DEPT. OF TRANSPORTATION
HAROLD TANIGUCHI, DIRECTOR
SE 416TH STREET OVERLAY
SHINGLES in PAVING DEMONSTRATION
OVERLAY PLAN - ENUMCLAW AREA

King County

SHEET 3 OF 3 SHEETS

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APPENDIX G. REVISED RAS SORTING, SAMPLING, AND TESTING OPERATIONS PLAN

This appendix includes the revised sorting, sampling, and testing operations plan as used in the field to prepare RAS for the demonstration. Please note that some attachments to this document have been removed to reduce the length.

Operations Plan

Introduction

This operations plan is intended to detail all proposed, procedures, assignments and equipment needed for the "re-sorting" of whole shingles at the Woodworth and Company's HMA plant in Lakewood, WA (2800 104th St. Ct. S, Lakewood, WA 98499).

Note: Background information about assumptions and a more detailed explanation of proposed sample sizes, test frequencies, and lab test methods (PLM, TEM, etc.) is included as Attachment E.

Planning and Site Preparations:

1. **Finalize Overall Operations Plans –** County and Woodworth review, edit as necessary, and approve these final plans for re-sorting / sampling / testing of whole shingles.
2. **Safety Plan and Instructions –** Woodworth to review, edit as necessary, and approve Attachment A – Proposed Safety Plan.
3. **Site Preparations –** Woodworth designates re-sorting asphalt "pad" area. Itemize specific locations for:
    a. Dump & pick operations;
    b. Administrative "table";
    c. Storage of any rejected items picked out of whole shingles (see Attachment B – Proposed Reject Items Categories and Sorting Instructions).
    d. Storage of re-sorted whole shingles to be quarantined while awaiting lab test results.
4. **Hose down / wash** sorting pad and reject storage pad as needed.
5. **Set up tables and other equipment** (see Attachment C – Sorting / Sampling Equipment List.
6. **"Ops Orientation Meeting"** (Wednesday, September 2, 7 a.m.) with all staff to be on-site during operations to review these plans, safety instructions, and channels of operations authority / communications.

Sampling:

7. **Woodworth's front end loader** operator scoops a bucket load of whole shingles from the existing stockpile of whole shingles (under the Quonset hut type shed). The loader operator then gently **"**sprinkles" the whole shingles into a single layer spread onto the sorting pad.

[**Note**: unless already done earlier by Woodworth, for the first five bucket loads, the loader operator should get a gross and tare weight across the truck scale to calculate an average weight per bucket load of whole shingles.]

8. Jim Lindahl and Bob Dutton create a load index number and **walk the spread load** to quickly characterize the shingles within the bucket load as spread on the sorting pad. (See Attachment D – Field Notes Log Sheet.) Jim identifies any likely, suspect asbestos containing material (ACM). If any found, Jim picks it up and sets it on the table for tagging and subsampling. One table will be used for clean material sampling and a second table will be used for suspected ACM sampling.

9. Jim **selects representative whole shingles** for sampling and brings them to the table for sampling. Jim **subsamples** (i.e., with a straight edge knife) approximately 2-inch square piece of each selected shingle. Jim **labels** the whole shingle and the sandwich baggie with corresponding sample index number. Jim puts sandwich baggie into gallon baggie labeled for each bucket load. Jim puts one-tab cut from whole shingle into a labeled baggie, and then into a bankers file box labeled for each bucket load.

10. Jim Lindahl **labels suspect ACM item** with a Sharpie directly onto the item, subsamples a piece, and places subsample in a correspondingly labeled sandwich zip lock baggie. Jim places any suspect ACM subsample baggie in labeled file box for later lab shipment prep. Jim places correspondingly labeled whole suspect ACM item in another labeled baggie, and places the baggie in a file box for archive storage and later retrieval if suspect item tests positive for ACM.

11. Bob Dutton **takes notes** as to shingles characterization (e.g., type, color, age), any reject items, and any suspect ACM Jim identifies.

12. Kris Beatty **photographs suspect any ACM items** and representative shots of **spread load** of whole shingles.

13. If Jim identifies a shingle that has had asbestos intentionally included as part of the original manufacturing process (i.e., a suspect ACM shingle), then the sorting crew team will pause and representatives of Woodworth, the County and any other agencies present will be called together to review the situation and the suspect ACM shingle. A decision will then be made after further assessment of the spread load and the remaining stockpile of whole shingles awaiting re-sorting.

<u>Shingles Sorting</u>:

14. Woodworth's **sorters walk the spread load and pick out any reject items working in sections** (see Attachment B). Each picked reject item is placed onto a 6 ML, poly sheet designated for like items (e.g., felt, mastic / plastic cement, other roofing materials, non-shingle debris, etc.).

15. Jim **approves the spread load** as "re-sorted enough" and then authorizes loader operator to scoop cleaned shingles into Woodworth dump truck for weighing.

16. Once full, the **truck driver scales the truck load** and then **unloads onto pad** designated for the re-sorted, whole shingles. [Note: Re-sorted shingles pile must be kept segregated from any other materials and quarantined until TEM test results come back from Lab/Cor.]

17. **Above steps / tasks** (8 through 16) **repeated** until 70 tons of clean, re-sorted shingles are stockpiled.

Sample Handling, Chain of Custody, Storage:

18. Bob **removes boxes** of "whole" samples and stores at King County DOT materials lab for archiving. (Includes whole samples both "rejects" and "whole, clean shingles".)

19. Jim and Kris **prep baggies of subsamples** for shipment.

20. Bob **completes separate lab chain of custody forms for "clean shingles" for TEM testing** and attaches to each gallon subsample baggie (one form per "bucket load")**.**

21. Bob **completes separate Lab/Cor chain of custody forms for "rejects" for PLM testing** and attaches to gallon subsample baggies (one form per "bucket load")**.**

22. **Subsamples transferred to lab(s).**

23. **Site is cleaned up** and all equipment removed.

Reject Items - Lab/Cor PLM Sample Prep and Analytical Methods:

24. **PLM samples prepared using gravimetric reduction.**

Re-Sorted Clean Shingles - TEM Sample Prep and Analytical Methods:

25. **TEM samples prepared using the following steps.**

    a. **Group Jim's "bucket load" subsamples into sets** of representing approximately three (3) tons of whole shingles per set.

    b. **Dry subsamples.**

    c. **Cut a representative "sliver" of Jim's subsample.**

    d. **Composite slivers to get to about 25 sets of slivers to run about 25 TEM tests.**

    e. **Weight and ash sliver sets**

    f. **Subsample resultant solids**

    g. **Conduct normal TEM analysis.**

Attachment B

Proposed Sorting Categories and Definitions

(Instructions for County and Woodworth sorting crew staff)

INTRODUCTION

Jim Lindahl will be primarily responsible for identifying "**suspect ACM**" items. If Jim identifies an item as "**suspect ACM**" it shall be handled as if it is ACM (i.e., labeled, subsampled and then contained in a 6 ML poly bag). See individual, proposed steps within the proposed sorting protocol below.

All sorting crew members on site (including County staff, consultant contractors and Woodworth employees) shall be encouraged to look for **suspect ACM** items. After initial orientation and training as to sort categories and standards of defining suspect ACM, any member of the sorting crew that identifies a **suspect ACM** item (or items) shall immediately point the item out to Jim.

Woodworth will designate one of their staff as the sorting "Supervisor" in charge of Woodworth's sorting crew and loader operator. The Supervisor is the project manager with ultimate operations and safety authority and responsibilities while County and contractor staff are on site. Jim will communicate via the Woodworth Supervisor for loader tipping / shingle sprinkling instructions, re-loading or re-sorted shingles, other traffic control (e.g., loading of the dump truck with clean, re-sorted shingles), and any observed safety or other operations concerns.

Once trained as to the following sorting categories and definitions, Woodworth's crew will be instructed to hand remove all "**sortable rejects**" and suspect ACM. "**Sortable rejects"** shall be defined as any item that is not a "clean asphalt shingle" essentially free of attached mastic or felt. Nails are not a **"sortable reject"** item because it is not feasible to hand sort nails (besides, the magnets will remove them later!).

Once Jim is satisfied he can not find any more suspect ACM, the Woodworth Supervisor shall have final authority to determine when a bucket load of re-sorted, clean asphalt shingles is ready for reloading into the Woodworth dump truck for weighing. The Woodworth Supervisor will help all members of the sorting crew define "sortable rejects" (e.g., how small are the "sortable" vs "non-sortable" items).

SORTING CATEGORIES: "Re-Sorted Shingles"
(For random subsampling and TEM testing)

"Clean, Asphalt Shingles Only", also known as **"Re-Sorted Shingles"**, means only asphalt shingles (e.g., three-tabbed asphalt shingles) and excludes other asphalt roofing products known as "rejects" for this re-sorting project. I.e., re-sorted shingles free of: sortable felt, sortable shingles with mastic, other items with mastic, built up roofing, rolled roofing, sheet roofing, slate shingles, clay tile shingles, etc.).

SORTING CATEGORIES: "Reject Items"
(For selected subsampling and PLM testing)

"Felt" also known as **"Tar Paper"** or **"Roofing Underlayment":**

"Mastic" also known as **"Roofing Plastic Cement"** includes any type of sortable item with noticable roofing adhesive material in paste-like form used as an adhesive or seal. Mastic shall be defined as any roofing adhesive material (e.g., glue, tar, roofing cement) that is foreign to the clean shingle as originally manufactured.

Metal: flashings; used plumbing stacks; used roof vents; gutters, and other metal roofing fixtures.

Plastic waste such as wrap from new shingle bundles, plastic cellophane strips from new shingles, plastic wrap from rolled roofing felt.

Roofing nails

Wood from repaired and new framing, roofing sheeting or other dimensional lumber.

Miscellaneous / Other Roofing Debris that is not a part of the clean, whole shingle and not included in the above categories.

Other Building Materials such as siding, floor tile, ceiling tile, etc., etc.

PROPOSED SORTING DEFINITIONS AND INSTRUCTIONS ACRONYMS

(To be used by County and Woodworth sorting crew staff)

Asbestos Containing Material (ACM) shall be defined as an material that is determined by PLM or TEM laboratory analysis as containing 1% or more of asbestos by visual estimate or by weight, respectively, as regulated by U.S. EPA's federal NESHAP program, related rules and advisory documents.

Asbestos Hazard Emergency Response Act (AHERA) are EPA rules as published in the Code of Federal Regulations, Chapter 40, Part 763, Subpart E.

Deleterious Materials, also known as "other foreign material" (OFM) or "extraneous materials", shall be defined by the King County RAS specification within the County's invitation to bid (ITB) is a category of prohibited contaminants (e.g., wood, plastic, metal, brick fragments) that should not be purposely included finished aggregate products such as virgin aggregates, recycled asphalt pavement (RAP), and RAS.

Invitation to Bid (ITB) – King County's request for bid document for the SE 416th Street Overlay Project and Shingles Recycling Demonstration, including all plans and specifications.

Manufacturers' Asphalt Shingle Scrap, also known as:

- "New shingle scrap",
- "Post-industrial shingle scrap",
- "Pre-consumer shingle scrap", or
- "Post manufacturer shingle scrap,"

includes rejected asphalt shingles or shingle tabs that are discarded in the manufacturing process of new asphalt shingles. This may include excess whole shingles, sheet cuttings, or "tabs". Not used in the King County demonstration project.

Mixed Roofing Material (MRM) includes all roofing debris from normal tear-off re-roofing jobs in commingled or mixed form: asphalt shingles; metal flashings, gutters, plumbing stacks and other metal roofing materials, nails; plastic shingles bundle wrap, flashings wrap, plastic plumbing stacks and other plastic roofing materials; felt underlayment; wood scrap from repair of roofing substructures and other wood debris; and paper scrap.

Multi-Layer Roofs are older style of re-roofing whereby the new course of asphalt shingles is installed on-top of the older, worn shingle layer(s) without "tear-off" of the old layer(s).

National Emission Standard for Hazardous Air Pollutants (NESHAP) is the U.S. EPA regulation governing asbestos management.[1]

Non-Shingle Debris is the other incidental waste materials normally removed as a part of regular re-roofing projects and may include items such as: wood; metal items such as from flashings and plumbing stacks; plastic from wrap and other sources; felt underlayment paper; etc.

Non-Sortable Items are roofing materials that can be visually identified as non-shingle debris but are too small to feasibly hand sort out from clean, whole shingles.

Polarized Light Microscopy (PLM) is the laboratory analytical technique used to visually estimate the percent of asbestos in bulk samples ….. It can differentiate between asbestos types, but cannot reliably detect asbestos in low concentrations (below 1%)[2].

RAS Specification is the set of provisions of the County's ITB pertaining to the materials quality and required methods of recycling the tear-off asphalt shingles into RAS.

Recycled Asphalt Shingles (RAS) means the intermediate crushed, screened product. RAS is most often processed into a form ready for use in hot-mix asphalt plants. Also known as "processed shingles".

Roofing Scrap generally refers to mixed roofing materials from tear-off demolition and reroofing operations. In addition to tear-off shingles, mixed roofing scrap may include non-shingle items such as:

- Recyclable metal: flashings; used plumbing stacks; used roof vents; gutters, and other roofing fixtures.
- Roofing nails.
- Plastic waste such as wrap from new shingle bundles, plastic cellophane strips from new shingles, plastic wrap from rolled roofing felt.
- Wood from repaired and new framing, roofing sheeting or other dimensional lumber.

Shingle Scrap is the more generic term and includes both manufacturers' and tear-off shingle scrap before processing. In the context of this *QA/QC Protocol*, the term refers to recyclable asphalt shingle scrap. In other documents, it may be used more generically to include other types of roofing shingles including cedar shake shingles, transite shingles, and other types of shingles.

[1] U.S. EPA's rules for National Emission Standards for Hazardous Air Pollutants (NESHAP) as per Code of Federal Regulations (CFR), Title 40, Volume 8, (Revised as of July 1, 2008) Part 61, Subpart M - National Emission Standard for Asbestos. (As accessed via the web site: http://www.epa.gov/asbestos/pubs/2003pt61.pdf.

[2] U.S. Environmental Protection Agency (EPA) web document: *Libby Sampling and Analysis*; http://www.epa.gov/libby/sampling.html (as accessed on 8-26-2009).

Single Layer Roofs have only one course of asphalt shingles.

Sortable Rejects shall be defined as any item that is not a clean, asphalt shingle that can be feasibly hand picked out of the bucket load of whole shingles spread out on the pad for sorting. "Sortable rejects" may include:

- Shingles with any significant mastic (also known as plastic roofing cement)
- Rolled or flat asphalt roofing products
- Loose felt
- Metal flashings, plumbing stacks, or other sortable metal items
- Plastic wrap, sheets, or other sortable plastic items

"Suspect ACM" Items are any product within the existing (400 ton) stockpile of sorted shingles or in the bucket load items sprinkled on the sorting pad that have visible asbestos fibers (e.g., old, asphalt shingles intentionally manufactured with asbestos). Suspect ACM items may also include other building materials such as asbestos pipe, insulation, slate roofing, slate siding, etc.

Tear-Off Asphalt Shingle Scrap, also known as "post consumer" or "used" asphalt shingle scrap, includes the shingle scrap derived from re-roofing projects whereby the old shingle layers are removed to prepare the roof surface for new shingles and / or other roofing materials.

APPENDIX H. WSDOT REPORT ON RAS SAMPLES SUBMITTED IN RESPONSE TO RFI

This appendix includes the Preliminary Results of Selected Lab Analyses By Washington State Department of Transportation for Recycled Asphalt Shingles (RAS) Samples Submitted in Response to King County's Request for Information.

Recycled Asphalt Shingles (RAS) Samples
Submitted in Response to King County's Request for Information

Preliminary Results of Selected Lab Analyses
By Washington State Department of Transportation

Background

In July 2008, the King County Solid Waste Division (KCSWD) produced and released a request for information (RFI) to obtain responses of information and product samples from current and potential shingle recycling operators that could eventually supply recycled asphalt shingles (RAS) to King County for the upcoming 2009 shingles in paving demonstration project. Written responses to the RFI were due on August 22, 2008. Three companies responded and submitted preliminary samples of RAS.

The KCSWD's LinkUp Program has initiated the Shingles in Paving Demonstration Project to help demonstrate the successful use of tear-off post-consumer RAS in hot mix asphalt (HMA) within a controlled study including extra materials testing and pavement monitoring. The RAS modified HMA will be used within a single, King County road maintenance "overlay" project proposed in July 2009.

This Project is being initiated by KCSWD in partnership with the King County Department of Transportation (KCDOT) and the Washington State Department of Transportation (WSDOT). This Project Team, together with help from a Project Advisory Group, produced the draft *RAS Material Quality and Supply Certification Specifications (RAS Specifications)* that were included in the July 2008 RFI packet.

WSDOT analyzed the preliminary samples submitted in response to the RFI. The RAS preliminary product samples were derived from tear-off asphalt shingle roofing scrap. KCSWD requested that RFI respondents provide a representative 25-30 pound sample of RAS product as currently produced. The lab analysis by WSDOT was conducted for preliminary research and specification development purposes; they represent early results of RAS product samples "as is" as provided in August 2008. The RAS samples were not required to meet the draft RAS specification for the RFI submittal.

Preliminary WSDOT Lab Analysis

This is a summary of the testing performed on preliminary samples of RAS submitted by three shingle recycling companies for use on the King County South County Overlay Project in 2009. To help emphasize the informational purposes of these preliminary WSDOT lab analyses, the companies have been indentified in this summary report as by "Company A", "Company B" and "Company C".

The purpose of the preliminary testing was to identify the physical properties of RAS and how it may impact the volumetric properties of HMA. **The samples were not required to meet the draft RAS specifications. This analysis was performed for informational purposes only.**

As seen in the picture above the RAS sample submitted by "Company B" was crushed finer than the samples submitted by "Company A" and "Company C"

RAS Gradation and Extraneous Materials

The aggregate and extraneous materials remaining after solvent extraction were tested by sieve analysis for comparison to the gradation specifications drafted for use on this project. Appendix A displays WSDOT's preliminary gradation averages from the three samples as of October 14, 2008.

Table 2 below represents WSDOT's preliminary results of the extraneous findings as of December 16, 2008.

All three supplier's products would meet the gradation specification; however, all of them would fail the extraneous materials specification and Company A's product was the only one that would have exceeded the maximum moisture content (as orally reported by WSDOT on December 24, 2008). The extraneous materials consisted primarily of fiber like material with a smaller fraction of wood, additionally Company B's material had one nail in it.

Table 2
Analysis of Extraneous Materials in Preliminary RAS Samples

Recommended Material standard	AASHTO specification	Company A RAS	Company B RAS	Company C RAS
A.	"Total Extraneous" = 3.0%	6.4%	2.5% (within spec)	9.8%
B.	"Light Fraction Extraneous" = 1.5%	5.9%	2.1%	9.7%
C.	"Free of whole, intact nails"	0 nails	1 nail	0 nails
D	Moisture = 5%	8.2%	2.7%	1.4%

Suggested RAS material standard for the King County demonstration project

A = Extraneous materials such as metals, glass, rubber, nails, soil, brick, tars, paper, wood, and plastic shall not exceed 3.0 percent by mass as determined on material retained on the4.75mm (No.4) sieve. (As per AASHTO specification MP 15, as proposed for amendment by subcommittee on materials (SOM), August 2008)

B = Lighter material such as paper, wood, and plastic shall not exceed 1.5 percent by mass as determined on material retained on the 4.75mm (No.4) sieve. (As per AASHTO specification MP 15, as proposed for amendment by SOM, August 2008)

C = RAS Product shall be entirely free of whole, intact nails. (As per the proposed, revised draft RAS specification for King County as of December 11, 2008)

D = The final RAS product shall not contain more than 5.0 percent moisture when tested in accordance with "FOP for AASHTO Total Evaporable Moisture Content of Aggregate by Drying." (See Attachment 1.) The Operator shall take necessary steps to ensure excessive moisture is not retained in the RAS stockpiles. (Draft King County RAS specification as of 12-11-2008; Section 2, Subsection 8.)

RAS Binder Content and Grade

Testing included an analysis of extracted and recovered asphalt binders from RAS and Recycled Asphalt Pavement (RAP) samples. The table in Appendix A lists the preliminary results of the percent binder (Pb) found in each of the three RAS samples.

The recovered asphalt binder samples were blended with typical Performance Graded (PG) asphalt and tested to measure high and low temperature properties. As expected

from other states' research, the results indicate an overall increase in the asphalt binder stiffness. [Quantified data not yet tabulated.]

The last battery of testing included mixing samples of typical ½ inch HMA with 3 and 5 percent RAS and 15% RAP. In summary the preliminary laboratory tests showed that 3% RAS from any of the three suppliers could be used with a typical ½ inch HMA and 15% RAP and still meet the mix design specifications. **It is important to note that these tests are preliminary in nature and additional testing should be conducted with materials representing the HMA to be used on the King County project.**

APPENDIX A

Gradation Averages: Preliminary RAS Samples

RAS "Company A"

Sieve	3/4"	1/2"	3/8"	#4	#8	#16	#30	#50	#100	#200	Pb
% Passing	100	100	97	89	86	67	47	39	31	22.1	19.7

RAS "Company B"

Sieve	3/4"	1/2"	3/8"	#4	#8	#16	#30	#50	#100	#200	Pb
% Passing	100	100	100	97	97	74	45	38	33	25.9	16.3

RAS "Company C"

Sieve	3/4"	1/2"	3/8"	#4	#8	#16	#30	#50	#100	#200	Pb
% Passing	100	100	97	90	86	66	46	40	32	24.4	22.8

APPENDIX I. KCRSD REPORT

This appendix includes the following sections from the Technical Support Document for SE 416th Street Overlay: Shingles in Paving Demonstration, completed by King County Materials Laboratory in January 2010:

- Acknowledgements
- Table of Contents
- Report

Appendices for this document have been removed to reduce the length.

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Technical Support Document for

SE 416th Street Overlay: Shingles in Paving Demonstration

King County Materials Laboratory

January 2010

EXECUTIVE SUMMARY

This document provides technical support for evaluating the use of post-consumer recycled asphalt shingles (RAS) as a component of Hot Mix Asphalt (HMA) for paving projects under the jurisdiction of the King County Department of Transportation (KCDOT). The Road Services Division of the KCDOT, in partnership with the Solid Waste Division of the King County Department of Natural Resources and Parks, and the Washington State Department of Transportation (WSDOT) Materials Laboratory conducted a pilot project to evaluate the use of post-consumer recycled asphalt shingles (RAS) in combination with recycled asphalt pavement (RAP) in Hot Mix Asphalt (HMA).

The King County Materials Laboratory (KCML) specifically assisted in selecting the pilot project roadway section, documented the pre-construction condition of the selected roadway, provided limited preliminary testing of the materials used, conducted quality control testing during construction, and coordinated post-construction testing. This document presents a summary of our work and participation in support of this project.

It has been a common practice to use RAP in HMA for many years on King County Roadways. Currently, up to 20 percent of the total weight of aggregate in the mix can consist of RAP. Incorporating post-consumer RAS in HMA on public roadways, however, is a relatively new concept in Washington State. Over the past several years various State and local municipalities across the country have allowed the use of RAS (tear-off shingles and manufacturers scrap) in roadway applications through provisional and permissive materials specifications. This demonstration project provides the first documented use of RAS on a public roadway within Washington State.

The potential to commonly use RAS in HMA mixes provides two major advantages. First, RAS contains a substantial amount of asphalt binder that could be substituted for a portion of the virgin asphalt binder. Secondly, recycling post-consumer shingles substantially reduces the amount of landfill waste.

To utilize RAS in pavements, deleterious materials such as nails and other extraneous products must first be removed. The RAS materials must then be tested to verify the product is substantially free of asbestos. In addition, the shingles need to be pulverized to a size that will ensure uniform mixing and to assist in the release of the RAS asphalt binder into the total mix.

An additional concern incorporating RAS is the type of asphalt binder in shingles. The asphalt binder used in roofing materials is typically stiffer than asphalt pavement binders. A

significantly stiffer asphalt binder may contribute to premature fatigue cracking of the roadway. Conversely, a stiffer asphalt binder may aid in reducing rutting over the long-term performance of the roadway.

Prior to construction, a preliminary mix design incorporating the proposed amount of RAS was conducted to verify the performance of the combined HMA mix. The demonstration project allowed for the use of 3 percent RAS and 15 percent RAP in the total HMA job mix for a combined total of 18 percent recycled materials. Preliminary HMA mix design testing was conducted by the WSDOT Materials Laboratory in Tumwater, Washington.

A two-mile section of roadway (SE 416th Street) located in south King County near the City of Enumclaw was selected for the pilot project. In September 2009 the roadway was overlayed with a 2-inch thick layer of HMA incorporating both RAP and RAS in designated Test Sections.

Initial observations and test results indicate that, when the virgin asphalt binder content is correctly adjusted, the addition of 3 percent RAS does not significantly impact the quality and placement of the HMA job mix. Further testing, analysis, and documentation of the roadway will continue for a minimum of three years to verify the long-term performance of the roadway.

1.0 INTRODUCTION

1.1 BACKGROUND

On August 21, 2007 the Solid Waste Division (SWD) of the King County Department of Natural Resources and Parks coordinated a meeting of potential stakeholders for the purpose of conducting a paving demonstration utilizing post-consumer recycled asphalt singles (RAS). Following the meeting, a paving demonstration advisory group was formed consisting of private contractors, consultants, and various public agency personnel to implement the project, including the Road Services Division (RSD) of the King County Department of Transportation.

In May of 2008, SWD secured an agreement with RSD to sponsor a paving project for the 2009 construction season. It was agreed, based on discussions with the paving demonstration advisory group and RSD, that the Hot Mix Asphalt (HMA) job mix would contain 3 percent RAS in the mix design. In addition, because typical asphalt roadways in King County can be constructed using up to 20 percent recycled asphalt pavement (RAP), 15 percent of the total mix would contain RAP.

1.2 ROADWAY SELECTION PROCESS

The available roadways considered for this project were limited based on a number of criteria. First, because of budget restraints, the selection was limited to roadways that were to be included as part of King County's 2009 Overlay Contract. Secondly, in order to provide

enough tonnage of asphalt to increase contractor interest and for analysis purposes, the roadway was restricted to a pavement section with an approximate minimum length of 2 miles. Based on these initial requirements, 5 roadways were found to meet the above criteria.

To further refine the selection, RSD personnel with extensive experience in roadway design and construction observed the condition of each roadway and provided a weighted qualitative score on ten different selection criteria. SE 416th Street received the highest combined score and was chosen as the best available candidate for the demonstration project. The rating criteria used and summation of scoring totals are included in Appendix A.

1.3 GENERAL OVERVIEW OF THE SELECTED ROADWAY CANDIDATE

SE 416th Street, within the project limits, is located in south King County, near the City of Enumclaw. The roadway runs east-west and serves as a 2-lane paved rural arterial with 2-foot wide paved shoulders. The project extended approximately 2 miles, beginning at the intersection of 212th Avenue SE (Station 10+20) and ending at 244th Avenue SE (Station 116+00). The general location is shown on the Vicinity Map, Figure 1, at the conclusion of the text.

The surface topography consists of gently rolling pastoral terrain overlaying glacial and lahar deposits of various soil types ranging from gravels to fine-grained silt. Beginning at 212th Avenue SE (Station 10+20) and travelling in an easterly direction, the roadway is relatively straight, level, and sited along an elevated area of the valley. At roughly one mile (Station 63+10) the road slowly descends to the valley floor and crosses over a short-span bridge at Newaukum Creek. From Newaukum Creek, the roadway gradually ascends over a hill near 236th Avenue SE (Station 89+10), and then returns to the valley floor and the end of the project at 244th Avenue SE (Station 116+00).

The project scope of work included planing bituminous surfaces, removal of raised pavement markers and other obstructions, and preleveling portions of the roadway as needed to construct final grade requirements. The entire roadway was then overlayed with a minimum 2-inch thick layer of HMA that, in designated sections, incorporated both RAP and RAS.

1.4 TEST SECTION LAYOUT

Initial observations of the road surface and surrounding topography, based on a brief site reconnaissance, suggested that the western half of the 2-mile long roadway section (Station 10+20 to Station 63+10) was in fair condition, typically exhibiting low to moderate longitudinal cracking in the wheel paths at intermittent locations. The eastern half of the roadway (Station 63+10 to Station 116+00) appeared to be in fair to poor condition, exhibiting a higher degree of deterioration as compared to the western half of the roadway section.

To account for the variability in pavement and underlying soil conditions, the roadway was divided into 4 separate Test Sections, each approximately ½ mile in length. The division

allowed for one Test Section each of the RAP only and RAP/RAS HMA mix to be sited on both the western and eastern portion of the roadway. Each Test Section required about 1000 tons of HMA to provide for a 2-inch thick overlay. The Test Section Layout for this project is shown in Table 1.

TABLE 1				
Se 416TH Street Overlay				
Test Section Layout				
Lane Description	**Test Section #1**	**Test Section #2**	**Test Section #3**	**Test Section #4**
Stationing	10+20 to 36+50	36+50 to 63+10	63+10 to 89+66	89+66 to 116+00
Lane 1 (eastbound)	HMA Mix with 15% RAP	HMA Mix with 3% RAS and 15% RAP	HMA Mix with 3% RAS and 15% RAP	HMA Mix with 15% RAP
Lane 2 (westbound)	HMA Mix with 15% RAP	HMA Mix with 3% RAS and 15% RAP	HMA Mix with 3% RAS and 15% RAP	HMA Mix with 15% RAP

A graphical depiction of the Test Section Layout is shown in Figure 2, at the conclusion of the text section of this report.

2.0 PRE-CONSTRUCTION CONDITONS

2.1 BACKGROUND

In late May 2009, as part of the King County overlay program, and prior to the final selection of SE 416th Street as the roadway candidate for this project, King County Maintenance crews milled out selected 40-inch wide strips of the pavement surface approximately 2.5 inches in depth within distressed wheel path areas. The milled areas were then patched with HMA. Detailed pavement conditions prior to milling and patching were not documented. In general, distressed areas were concentrated in the driving lane wheel paths in the form of longitudinal cracking.

2.2 PAVEMENT CONDITION SURVEY METHODS

Two separate pre-construction pavement condition surveys were conducted on the road-way prior to overlay operations. In the late spring/early summer of 2009, KCML conducted a walking survey using methodologies generally prescribed by ASTM D-6433-03 (ASTM) and the Northwest Pavement Management Association. In July 2009, WSDOT conducted a drive-through survey using laser and other sensing devices mounted to a distress data

collection van. Pavement distresses observed during the surveys were categorized and quantified for the purpose of developing a Pavement Condition Index (PCI) for the entire roadway and each Test Section.

Typically, pavement condition surveys are conducted as part of an agency-wide Pavement Management Program. The general intent of the survey is to provide a method of measuring and documenting the current condition of the pavement for comparison with future evaluations. These measurements assist in determining the rate of deterioration and consequently, needs for rehabilitation or repairs. Under many circumstances, the entire roadway is not surveyed for an agency-wide pavement management system. Instead, a percentage of the overall roadway is selected using random sampling principles in order to obtain a sufficient size and quantity of sample lots that statistically represent the overall roadway length.

Completion of the pavement condition survey will result in the generation of one or more PCI's. PCI is a numerical indicator that rates the present condition of the pavement 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. The PCI is also an indicator of the structural integrity and potential operational or safety issues associated with the pavement.

Pavement deterioration is a curvilinear relationship that accelerates or increases with time and exposure. The ASTM survey method includes up to 19 different categories of distress. This project utilized five distress categories including alligator cracking, longitudinal cracking, transverse cracking, rutting, and patching for flexible pavements. Each category of distress is qualitatively classified as having a Low, Medium, or High level of severity. An initial uncorrected deduct value is then determined for each distress category and severity level as a function of the distress density (percent of total area or length).

The final deduct value was determined based upon the total sum of initial deduct values and number of different distress categories within a sample lot or section of roadway. The total corrected deduct value is subtracted from 100 to determine the overall PCI. ASTM suggests the 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

2.2.1 Pavement Condition Survey (KCML)

A pavement condition survey of the entire roadway, within the project limits, was conducted by KCML personnel prior to overlay of the roadway. The survey was conducted over a period of time from 6-29-09 through 8-4-09 during generally sunny to partly cloudy weather conditions. The survey was performed by walking the entire roadway and documenting pavement distress conditions generally following methodologies prescribed by ASTM D-6433 and the Northwest Pavement Management Association.

For this site specific survey, the entire length of roadway between fog lines was evaluated in 100-foot intervals, beginning at Station 10+20 and ending at Station 116+00. The lateral extent of distressed areas was measured using a wheeled-tape, with the distresses being noted separately for each traffic lane.

On the basis of the observed distresses, a PCI rating was developed for the entire road as well as for each Test Section. The ratings are summarized in Table 3.

TABLE 3	
SE 416th Street Overlay	
KCML Pre-Construction Pavement Condition Indices (PCI)	
Test Section 1	78.0
Test Section 2	72.0
Test Section 3	44.0
Test Section 4	70.0
Overall Rating	66.0

A detailed breakdown of distress quantities for each Test Section is presented in Appendix A. Plan view graphical representations depicting the categories and level of distress in 100-foot sections along the roadway alignment are also included in Appendix A.

2.2.2 Pavement Condition Survey (WSDOT)

On 7-10-09, The WSDOT Materials Laboratory conducted a pavement condition survey utilizing laser equipment mounted to a distress data collection van. The van is also equipped to film the entire roadway surface during testing. WSDOT designates a Pavement Condition Index (PCI) as a Pavement Structural Condition (PSC), documenting the forms and severity levels of distress including alligator cracking, longitudinal cracking, transverse cracking, and patching for flexible pavements. In addition to PSC testing, the van is capable of documenting pavement rutting condition (PRC) and roughness based on the International Roughness Index (IRI). A brief definition of each rating system is presented below.

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).

For calculation of the PSC, laser images of the pavement surface are obtained utilizing the distress data collection van. The van is driven along the Test Section collecting images while travelling near the posted speed limit. These images are collected every 25.4 feet, scanning the entire width of the lane. The images are then evaluated with other pertinent roadway information, such as length and area. An operator then views the images in a frame by frame progression made possible by the vendor of the collection van, in this case Pathway Services out of Oklahoma. The operator, using the "WSDOT Pavement Surface Condition Rating Manual", records pavement distresses as they appear. Utilizing special hot keys on the keyboard, the operator marks the distress by type, severity, and extent as they show up on the images. The computer program then compiles all distresses and their associated deduct values to calculate the PSC.

Pavement Rutting Condition (PRC)

PRC is a score representing the extent of rutting present in the rated lane. This is accomplished by 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. Utilizing a special program developed by the vendor, INO out of Canada, the rut depths for each of the wheel paths are measured. The rating scale for the PRC ranges from 100 (no rutting) to 0 (deep rutting dependent on the length). Typically, a roadway would be considered for rehabilitation when the PRC rating is 50 or below.

International Roughness Index (IRI)

IRI is a measurement for roughness of the pavement surface. The collection van is outfitted with two accelerometers, one for each wheel path. As the van travels over the test site these accelerometers measure the movement of the van. 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 4, when rating the IRI:

TABLE 4	
SE 416th Street Overlay	
IRI Roughness Scale	
IRI (inches/mile)	**Pavement Rating**
Below 95	Very Good
95-170	Good
170-220	Fair
220-320	Poor
Above 320	Very Poor

It should be noted that, for consistent readings, the van should be able to move through the measured section unimpeded. Stop signs, lights, turning vehicles all affect the roughness

readings since the van must slow down or brake then accelerate causing up and down motion of the van.

WSDOT Pavement Condition Summary

Test results from the WSDOT pavement condition survey are summarized in Table 5.

TABLE 5			
SE 416th Street Overlay			
WSDOT Pre-Construction Pavement Condition Survey			
Test Section	**PSC**	**PRC**	**IRI**
Test Section 1	43.4	80.1	83
Test Section 2	24.8	76.9	94
Test Section 3	26.8	76.7	185
Test Section 4	29.8	79.4	132
Overall Rating	31.2	79.0	124

Notes: PSC = Pavement Structural Condition (WSDOT)
PRC = Pavement Rutting Condition (WSDOT)
IRI = International Roughness Index (inches/mile)

The recorded pavement condition of the roadway surface varied significantly when comparing data obtained from KCML and WSDOT. A comparison of the ratings is presented in Table 6.

TABLE 6		
SE 416th Street Overlay		
Comparison of KCML and WSDOT Pavement Rating Conditions		
Test Section	**KCML Ratings (PCI)**	**WSDOT Ratings (PSC)**
Test Section 1	78	43.4
Test Section 2	72	24.8
Test Section 3	44	26.8
Test Section 4	70	29.8
Overall Rating	66	31.2

The pavement condition rating system for both PCI and PSC is relatively equivalent. Both techniques rely substantially on qualitative methods for rating the road surface. The discrepancies found in the above recorded values are most likely due to subjective and qualitative interpretation for the rated severity of observed distressed areas. KCML interpreted the majority of longitudinal cracking as low severity, while WSDOT generally measured these distresses as moderately severe. In addition, KCML designated the majority of asphalt patching as low severity. WSDOT documented the patching as medium severity.

The pavement rutting condition survey indicated minimal rutting within the roadway. Rutting values were similar in all Test Sections. The roughness condition for Test Sections 1 and 2 rated very good. Test Sections 3 and 4 rated from good to fair, respectively.

2.3 PAVEMENT CORING

On 8-5-09, a total of 16 asphalt concrete pavement (ACP) cores were obtained from the roadway within the project limits. Four cores were retrieved from each Test Section, two from each lane within the Test Section. The 4-inch diameter cores were measured to determine overall and individual layer thickness. At each core location the underlying surfacing material was excavated to expose the subgrade soils. A summarized description of the pavement thickness and underlying materials found in each Test Section is presented below:

- **Test Section 1 (Cores 1 through 4)**: Average pavement thickness was approximately 4.5 inches in depth. On average, roughly 3 inches of crushed surfacing materials were found below the asphalt pavement. Silty gravel (GM) was found below the crushed surfacing layer.

- **Test Section 2 (Cores 5 through 8)**: The pavement section was similar to Test Section 1, consisting of 4.5 inches of ACP overlaying 3 inches of crushed surfacing. Silty gravels were encountered below the crushed surfacing layer.

- **Test Section 3 (Cores 9 through 12):** The pavement section consisted of about 4.5 inches of ACP overlaying approximately 2.0 inches of Bituminous Surface Treatment (BST) consisting of densely compacted gravels bonded with a thin asphalt binder. Silty sand (SM) was encountered below the BST layer.

- **Test Section 4 (Cores 13 through 16):** The pavement section consisted of 5.5 inches of ACP overlaying about 2.0 inches of Asphalt Treated Base (ATB). Silty sands were typically found below the ATB layer.

Graphical logs of the asphalt cores and excavated underlying soils, and an associated Exploration Map are presented in Appendix B.

2.4 BORINGS

Subsurface testing was conducted by KCML on 8-6-09. A total of six exploratory borings were drilled within the right-of way of the roadway. At least one borehole was sited in each Test Section to obtain information on subsurface soil conditions throughout the alignment. The borings were advanced to a maximum depth of 11.0 feet below ground level using a truck-mounted drill rig equipped with a twelve-inch diameter open flight auger.

The relative density of granular soils and consistency or stiffness of cohesive soils was estimated based on drilling effort and visual observations. Disturbed, but representative, samples were obtained at various depths and returned to KCML for testing, as needed. The boring logs and related laboratory test results are included in Appendix B. A general description of the soils encountered in each Test Section is as follow:

- **Test Section 1**: Medium dense becoming dense silty gravel (GM)

- **Test Section 2**: Medium dense becoming dense silty gravel (GM) or silty sand (SM)
- **Test Section 3**: Loose silty sand (SM)
- **Test Section 4**: Loose organic silt (OL) or silty sand (SM)

No groundwater was encountered in any boreholes during drilling.

2.5 FALLING WEIGHT DEFLECTOMETER TESTING (FWD)

On 8-5-09 the WSDOT Materials Laboratory conducted pre-construction falling weight deflectometer (FWD) testing along the roadway. The FWD is a non-destructive testing device used to evaluate the physical properties of the pavement section and near surface soils. The device is capable of applying dynamic loads to the pavement surface, similar in magnitude and duration to that of a heavily loaded commercial vehicle. The pavement vertical deflection combined with known layer thicknesses are then used to calculate the in-situ resilient elastic moduli of the pavement structure and subgade moduli of the underlying soils. This information is then used to predict reaction to the pavement structure and subgrade soils from long-term traffic loading.

Testing was performed in the center of each lane at 200-foot intervals. In general, testing found a significant difference in total deflection of the pavement structure when comparing combined Test Sections 1 and 2, and Test Sections 3 and 4. An increase in deflection is an indicator of reduced capacity to support traffic loads over time before failure of the roadway. Deflections are measured in mils. A mil is a linear unit of diameter equal to 0.001 of an inch. Average deflections for Test Sections 1 and 2 were typically below 20 mils. In Test Sections 3 and 4, deflections were recorded near or above 30 mils.

Recorded subgrade moduli were comparable to measured deflections. The higher the subgrade moduli value, the more suitable the underlying soils are to withstand traffic loading over time. The uncorrected subgrade moduli measured in Test Sections 1 and 2 averaged about 40,000 pounds per square inch (psi). In Test Sections 3 and 4, the recorded subgrade moduli generally ranged below 15,000 psi.

During testing, the affected area or extent of the deflection was also recorded. In general, the longer the extent or length of deflection, the stiffer the asphalt structure. The overall area of each test location along the entire roadway was consistently measured to be on the order of 18 feet. A value falling within this deflection extent would relate to a relatively thin asphalt structure (less than 4 inches in depth). FWD test data is included in Appendix C. A summary of pre-construction FWD values are presented in Table 7.

TABLE 7									
SE 416th Street Overlay									
Pre-Construction Falling Weight Deflectometer Value Averages									
	Test Section 1		Test Section 2		Test Section 3		Test Section 4		Overall Roadway Average
	Right	Left	Right	Left	Right	Left	Right	Left	
Deflection (mils)	18	13	17	14	34	36	27	35	24
Subgrade Moduli (ksi)	51	42	38	45	12	11	13	11	28
Area (ft)	17	18	17	18	17	18	18	18	18

Note: Right = Eastbound Lane
Left = Westbound Lane
ksi = Kips per Square Inch

3.0 PRELIMINARY MATERIALS TESTING

3.1 WSDOT MATERIALS LABORATORY PRELIMINARY MATERIALS TESTING

For this project, the WSDOT Materials Laboratory served as the primary leader for developing the HMA job mix design. A HMA mix design using the proposed virgin asphalt binder and aggregates was first developed by the Contractor, Woodworth and Company. The design was then submitted to WSDOT for further development and the incorporation of RAP/RAS materials into the final HMA job mix design. We understand that the WSDOT Materials Laboratory is providing a separate report documenting the methods, procedures, and outcome of the mix design.

In general, it was determined that the target value for the virgin asphalt binder content alone was 5.6 percent by weight of the total mix. When including 15 percent RAP and 3 percent RAS, the proportions were recommended at 4.3 percent virgin asphalt binder, 0.6 percent asphalt binder from RAP, and 0.7 percent asphalt binder from RAS. The final mix design is included in Appendix D.

3.2 KCML PRELIMINARY MATERIALS TESTING

KCML's responsibility for preliminary materials testing was limited to equipment calibration and RAS testing for gradation, extraneous materials, and moisture, prior to mixing with RAP. In addition, we sampled the initially proposed designated stockpile of RAS for asbestos testing. Asbestos testing was performed by others.

3.2.1 Preliminary Asbestos Sampling and Testing for RAS

This report provides a brief summary of KCML involvement in sampling and testing for asbestos in RAS. We understand a detailed account of the testing process and documented events will be prepared by others.

For this project, the RAS supplier was responsible for inspecting and verifying that RAS materials used were free of asbestos containing material. During a site visit to the asphalt plant on 8-11-09, we were directed by RSD Management to sample and deliver materials obtained from the proposed designated RAS stockpile for asbestos testing. Twenty random samples were obtained from the stockpile. The materials were then delivered to the selected testing companies by King County Maintenance Environmental Unit personnel.

Each sample was tested for asbestos using Polarized Light Microscopy (PLM). PLM test results showed no detection of asbestos. Of the twenty samples, five sub-samples were additionally tested using Transmission Electron Microscopy (TEM). The test results found that 3 of the 5 sub-samples contained above one percent of asbestos, ranging from 1.64% to 5.94%. On the basis of these findings the project was put on temporary hold until this issue could be resolved.

Upon consultation with King County and their Consultants, the Contractor prepared a new and separate stockpile, removing asbestos suspect materials including tar paper, shingles with aluminum coating, rolled up roofing, mastic, and patching materials. The newly created stockpile was then tested for asbestos and none was detected.

3.2.2 Preliminary Testing of RAS for Gradation, Extraneous Materials, and Moisture

Three RAS samples were obtained at the final accepted Plant stockpile on 9-10-09 by SWD personnel and delivered to our laboratory for acceptance testing. Each sample was tested for conformance to project specifications for gradation, extraneous materials, and moisture content. Project specifications were as follows:

Gradation Requirements: The final RAS product shall be processed so that 100 percent passes the ½ sieve and a minimum of 95 percent passes the 3/8 inch sieve when tested in accordance with the test method in WSDOT Materials Manual “FOP for WAQTC/AASHTO for Sieve Analysis of Fine and Coarse Aggregates (WSDOT Test Procedure T 27/11).

Requirements Regarding Extraneous Waste Materials: The final RAS product to be used in the HMA shall be substantially free of extraneous waste materials and entirely free of whole, intact nails. Lighter extraneous material such as paper, wood and plastic shall not exceed 1.5 percent by mass as determined on material retained on the No. 4 sieve. Total extraneous materials including metals, glass, rubber, nails, soil, brick tars, paper, wood and plastic shall not exceed 3.0 percent by mass as determined on material retained on the No. 4 sieve. The method of sampling and testing shall be in accordance with “FOP for AASHTO Standard Practice for Sampling Aggregates” and “FOP for WAQTC/AASHTO Sieve Analysis of Fine and Coarse Aggregates (WSDOT Test Methods T 2 and T 27/11).

RAS Moisture Content: The final RAS product to be used in the HMA shall not contain

more than 5.0 percent moisture when tested in accordance with “FOP for AASHTO Total Evaporable Moisture Content of Aggregate by Drying (WSDOT Test Method T 255). The Shingle Recycling Operator shall take the necessary steps to ensure excessive moisture is not retained in the RAS stockpiles.

The RAS final stockpile test results are summarized in the Table 8 and included in Appendix D.

TABLE 8
SE 416th Street Overlay
RAS Final Stockpile Test Results Summary

Test Procedure	Requirement	Lab Sample KC-09-1122	Lab Sample KC-09-1123	Lab Sample KC-09-1124
Gradation, 1/2-inch sieve	100% Passing	99%	98%	98%
Gradation, 3/8-inch sieve	95% Minimum Passing	94%	92%	93%
Lighter Extraneous Material	1.5% Maximum	0.06%	0.01%	0.03%
Total Extraneous Material	3.0% Maximum	0.06%	0.01%	0.03%
Moisture Content	5.0% Maximum	10.0%	9.3%	10.8%

Test results revealed that the materials sampled did not meet the gradation or moisture content requirements. The materials did meet the requirements regarding extraneous waste materials.

We understood the RAS materials would be further reduced in size as the material was blended with RAP in the final grind, prior to entering into the mixing drum. In addition, for this project, the initial moisture content was not a critical issue. Generally, excessive water content is a concern if the material was first purchased separately from the RAS supplier, based on total weight. For this project, the Contractor served as both the RAS and HMA supplier. The known moisture content was used to aid in adjusting the mix proportions during production.

Therefore, in our opinion, the RAS materials substantially met the engineering intent for this project and were accepted for use

4.0 CONSTRUCTION INSPECTION AND QUALITY CONTROL TESTING

The Contractor, Woodworth & Company, began construction operations on 9-21-09 and proceeded through 9-25-09. The work was accomplished in warm dry weather throughout the week. A summary of work performed each day is presented below.

Road Preparation (9-21-09)

The Contractor prepared the roadway for paving, which included grinding existing pavement at intersections to match grades, removal of raised reflectors, and preleveling areas with conventional HMA to provide for the required finish grade. The thickness and extent of the preleveled locations were documented by King County Construction Services (KCCS) inspection personnel.

Paving Day 1 (9-22-09)

The Contractor began overlay operations at the east end of the project (244th Avenue SE), paving Test Section 4 with the RAP only HMA mix. KCML performed all required testing to verify the quality and placement of the job mix. These tests included asphalt binder content, gradation, maximum theoretical specific gravity, volumetric tests, and in-place density tests.

KCCS verified and recorded material quantities, weather conditions, laydown temperature, equipment and personnel used, and the extent of preleveling on other test sections. In addition, the Contractor provided their own testing services to further confirm the quality of materials and laydown procedures. Test results verified the HMA job mix, mix placement, and compaction met project specifications.

In preparation of paving with the RAP/RAS mix the following day, the Contractor requested a conference call with King County and WSDOT personnel regarding adjustment of the virgin asphalt binder. Based on their experience utilizing recycled shingles in previous projects placed on private property, the Contractor was concerned that the RAS portion of the mix would not fully function as an asphalt binder when incorporated into the mix.

Therefore, the Contractor recommended to increase the virgin asphalt binder by 0.2 percent, for a total of 4.5 percent virgin asphalt binder, while still maintaining 15.0 percent RAP and 3.0 percent RAS for Test Section 3. It was the consensus of all parties to modify the mix as described above.

Paving Day 2 (9-23-09)

The Contractor paved Test Section 3 with the RAP/RAS added HMA mix. Test results found high asphalt binder content ranging above 6 percent. In addition, the fines content (aggregate materials passing the U.S. #200 sieve) was at or slightly above the maximum amount allowed. The air void content of the mix was also much lower than anticipated. In-place density tests were above 96 percent of the maximum theoretical specific gravity, confirming the low air void content.

The high asphalt binder content and increase in fines were not visually apparent on the pavement surface. The surface appeared similar to Test Section 4 placed the previous day. In addition, recycled shingle fragments were not obviously noted. Upon careful examination, however, some very small pieces of shingle fragments could be found.

Following placement, all parties met and agreed that the RAP/RAS HMA mix needed to be adjusted prior to proceeding to Test Section 2. It was decided that the Contractor could proceed to pave Test Section 1 on 9-24-09 using the RAP only HMA mix.

Paving Day 3 (9-24-09)

As agreed by all parties, Test Section 1 was paved using the RAP only HMA mix. Test results verified satisfactory quality of the job mix and acceptable placement and compaction.

In preparation of paving Test Section 2 with the RAP/RAS HMA mix the following day, the Contractor recommended to lower the virgin asphalt binder content back to the level proposed in the mix design (4.3 percent). In addition, the Contractor would attempt to reduce the fines content in the overall mix by cleaning out the baghouse.

Paving Day 4 (9-25-09)

The Contractor completed overlay operations by paving Test Section 2 with the adjusted RAP/RAS HMA mix. Testing indicated that the quality of the job mix was now in compliance. However, the fines content of the aggregate still ranged within the upper limits of the specification. Compaction testing indicated the average relative density of the new overlay to be slightly over the minimum requirement of 92 percent of the maximum theoretical specific gravity.

The appearance of the pavement surface was typical of a well-placed and compacted HMA roadway. A few intermittent shingle fragments and extraneous materials including wood, rubber, glass and wire could be located and pulled from the compacted surface. The diameter of these materials was generally less than 1/2-inch in thickness. However, some RAS fragments, in the shape of strands, measured nearly 4 inches in length.

Documentation during construction, including daily field reports, density test results, and all other related laboratory test results is provided in Appendix E.

5.0 POST-CONSTRUCTION TESTING

Following final paving operations, the roadway was restriped and immediately opened to traffic. In addition, stationing was reestablished to use as a reference for post-construction testing and documentation. Post-construction testing included pavement condition rating utilizing the WSDOT distress data collection van, recording deflections using the WSDOT falling weight deflectometer, and skid resistance testing conducted by the King County Sherriff's office.

5.1 POST-CONSTRUCTION PAVEMENT CONDITION SURVEY (WSDOT)

On 12-2-09, the WSDOT Materials Laboratory conducted a post-construction pavement condition survey utilizing the distress data collection van. Test results from the WSDOT post-construction pavement condition survey are summarized below in Table 9.

TABLE 9			
SE 416th Street Overlay			
WSDOT Post-Construction Pavement Condition Survey			
Test Section	**PSC**	**PRC**	**IRI**
Test Section 1	100	95.6	68
Test Section 2	99.8	97.6	60
Test Section 3	100	95.0	88
Test Section 4	99.7	96.1	78
Overall Rating	99.9	96.1	74

Notes: PSC = Pavement Structural Condition (WSDOT)
PRC = Pavement Rutting Condition (WSDOT)
IRI = International Roughness Index (inches/mile)

The survey revealed that the newly paved roadway surface is in near perfect visual condition with minutely recorded rutting. The roughness (IRI) of the roadway measured below 95 in all Test Sections indicating a relatively smooth surface. However, Test Sections 3 and 4 rated about 20 points higher than Test Sections 1 and 2. This may be due to traveling over the existing Newaukum Creek Bridge located in Test Section 3 and/or accelerating or decelerating during testing.

The survey will serve as a baseline for documenting deterioration of each roadway Test Section over time.

5.2 POST-CONSTRUCTION FALLING WEIGHT DEFLECTOMETER TESTING

WSDOT Materials Laboratory also conducted post-construction falling weight deflectometer (FWD) testing along the roadway on 10-14-09. Data obtained from testing is in the process of analysis. Analysis of the information was not completed prior to the release of this report and will be included in a supplemental report.

5.3 SKID RESISTANCE TESTING

Roadway skid resistance testing was conducted by the Major Accident Response and Reconstruction Unit (MARR) of the King County Sherriff's office. Within each Test Section, skid resistance testing was performed during dry pavement conditions on 10-12-09 and during wet pavement conditions on 1-04-10.

The tests were conducted using both Vericom VC 2000 and VC 3000 Braking Computer Systems. The braking computer system calculates a drag factor which is used throughout the accident reconstruction industry as an indicator of skid resistance, and has been used

by the MARR Unit for over 15 years involving thousands of test skids. The drag factor is a unitless value and is used to calculate the resistance of an object in motion. According to Vericom's website, the normal range for drag factors of various vehicles is presented in Table 10.

TABLE 10	
SE 416th Street Overlay	
Normal Range for Drag Factor (F)	
Passenger Vehicles with Standard Brakes	0.75 ± 5%
Passenger Vehicles with ABS Brakes	0.85 ± 5%
Motorcycles	0.9 ± 10%
Commercial Vehicles	0.62 ± 10%

Note: Pickup trucks are 5% less than a passenger vehicle.

Vehicles used during dry skid resistance testing included a 2007 and 2009 Ford Expedition, a 2005 Ford Taurus and a 1999 Dodge Caravan. One 2006 Ford Expedition, two 2007 Ford Expeditions, and one 2009 Ford Expedition were utilized during wet skid resistance testing. When available, tests were conducted using both conventional braking and anti-lock braking (ABS) systems. A summary of the skid test results for both dry and wet surface conditions are summarized in Table 11.

TABLE 11				
SE 416th Street Overlay				
Drag Factor Test Results in Both Dry and Wet Road Conditions				
Test Section	Dry Roadway		Wet Roadway	
	Conventional Braking	Anti-Lock Braking	Conventional Braking	Anti-Lock Braking
Test Section 1	0.71	0.83	0.66	0.79
Test Section 2	0.70	0.86	0.68	0.82
Test Section 3	0.67	0.81	0.66	0.80
Test Section 4	0.72	0.87	0.73	0.83
Overall Rating	0.70	0.84	0.68	0.81

Test results indicated that the overall skid resistance for both dry and wet conditions recorded on SE 416th Street was comparable to those found on other similar King County Roadways. Skid resistance test reports submitted by the MARR Unit of the King County Sherriff's Office are included in Appendix E.

6.0 CONTINUING TESTING AND ANALYSIS

Continuing testing and analysis in support of the demonstration project, and to supplement this report, will include the combined analysis of falling weight deflectometer data, current pavement thicknesses, subsurface conditions, and traffic analysis to predict the long-term performance of each Test Section.

Based upon the refined predictions, we will then be able to more accurately determine the impact of using RAS in HMA. The analysis is expected to be completed and made available for distribution by March 2010. A walking pavement condition survey will also be conducted by KCML to provide an additional baseline for determining long-term performance.

KCML is further committed to closely monitor the structural performance of the roadway for a minimum of three years. At that time, a judgment on the long-term structural impact of using post-consumer shingles could then be considered. Further monitoring and analysis of the retrieved data will include the following procedures:

- Conduct a yearly pavement condition survey by walking the site and documenting all distressed areas.
- Conduct a yearly pavement condition survey utilizing the WSDOT distress data collection van.
- After three years of service, conduct skid testing in both dry and wet conditions.
- Perform analysis of the above retrieved data and submit a supplemental report summarizing the findings and provide recommendations for the continued use of RAS on public roadways in King County.

7.0 SUMMARY, FINDINGS, AND CONCLUSIONS

7.1 SUMMARY

We have completed our initial documentation and analysis of the SE 416th Street Overlay: Shingles in Paving Demonstration. The purpose of the Demonstration project was to determine the consequence of incorporating recycled asphalt shingles (RAS) into the total HMA mix design. The use of post-consumer (tear-off) shingles in roadway paving is a relatively new concept. This project represents the first known attempt to incorporate RAS into a HMA job mix for use on a public roadway in King County.

The demonstration project allowed for the use of 3 percent RAS and 15 percent RAP in the total HMA mix. Preliminary HMA mix design testing was conducted by the WSDOT Materials Laboratory in Tumwater, Washington. To determine short term and long term impacts, KCML developed and implemented a program to document the pre-construction condition of the roadway. Construction was closely monitored by documenting field activities and performing quality control testing on the materials used and their placement. Initial post-construction testing was then conducted to provide a baseline for future evaluation and documentation on the long-term performance of this roadway.

7.2 FINDINGS

7.2.1 Pre-Construction Conditions

Pre-Construction Pavement Condition Surveys

Pavement condition ratings between KCML and WSDOT varied significantly when comparing pavement condition indexes (PCI). KCML documented an overall rating of 66 as compared to an overall rating of 31 recorded by WSDOT. This is likely due to the subjective and qualitative interpretation for the rated severity of observed distressed areas.

The majority of deteriorated sections were located in the wheel paths of the roadway. KCML interpreted the majority of cracking as low severity longitudinal cracking, while WSDOT generally measured these distresses as moderately severe. In addition, KCML designated the newly placed asphalt patching constructed by King County Maintenance in May 2009 as low severity. WSDOT documented the patching as medium severity.

Despite the discrepancy of the qualitative analysis of the pavement surface, data from both surveys can and will be used to aid in determining future deterioration of the pavement, providing valuable information as one indicator for the long-term performance of the roadway.

The pre-construction pavement rutting condition survey revealed minimal rutting within the roadway. Rutting values were similar in all Test Sections. The roughness condition for Test Sections 1 and 2 rated very good. Test Sections 3 and 4 rated from good to fair, respectively.

Pre-Construction Physical Testing Summary

Physical testing of the roadway, included determination of asphalt thickness, observation of subsurface conditions, and falling weight deflectometer (FWD) testing. Retrieved asphalt cores measured an average thickness of 4.5 inches in Test Sections 1 through 3 and 5.5 inches in Test Section 4. In general, underlying soils in Test Sections 1 and 2 consisted of medium dense silty gravel or silty sand. Underlying soils in Test Sections 3 and 4 consisted of loose silty sands or organic silt.

FWD testing further verified underlying subgrade strengths. Test Sections 1 and 2 measured uncorrected subgrade moduli of roughly 40,000 psi. The recorded uncorrected subgrade moduli in Test Sections 3 and 4 were generally below 15,000 psi. The above data will be used in a future report to predict the long-term performance for each Test Section.

7.2.2 Preliminary Materials Testing

Preliminary Asbestos Testing Sampling and Testing for RAS

Test results using polarized Light Microscopy (PLM) methods detected no asbestos in the initial designated processed RAS stockpile. However, additional testing using Transmission Electron Microscopy (TEM) techniques did result in detecting a small percentage of asbestos in some samples.

To ensure substantial absence of asbestos in the finish RAS product, another stockpile was prepared by carefully hand sorting the shingles and removing felt, tar paper, patching material and other deleterious material that may contain asbestos. No asbestos was detected following testing of the new stockpile. This indicates that with proper sorting and inspection, RAS can be processed in a manner resulting in an asbestos-free product. Accepted processing and testing protocols are needed and must be followed to sufficiently address environmental issues when commonly using RAS.

Preliminary Testing of RAS for Gradation, Extraneous Materials, and Moisture

Preliminary testing prior to production revealed that the RAS samples did not specifically meet the gradation requirements. In addition, the moisture content was above specification limits. The amount of extraneous materials found was below the maximum required limit.

We understood, for this project, the RAS would be further reduced in size when mixed and re-ground with RAP, prior to entering the drum mixer. In addition, the mix was adjusted to account for the amount of water during production. Therefore, we believed the product was adequate for use in this project. Further standardized processing techniques and quality control measures may need to be implemented, if RAS is to be routinely incorporated into the HMA mix.

7.2.3 Construction, Inspection, and Quality Control Testing

Construction inspection and quality control testing verified that, except for Test Section 3, all Test Sections substantially met project specifications and materials verification. In Test Section 3, high virgin asphalt binder content in concert with, to a lesser extent, high aggregate fines content led to low air voids in the HMA job mix. In-place density tests further verified air void loss.

It was evident the addition of virgin asphalt binder in Test Section 3 was not needed to supplement the suspected lack of functional RAS-embedded asphalt binder. The fuller release of these binders may be attributed to double grinding RAS before entry into the drum mixer.

The graded size of RAS and interdependent relationship with the total percent of asphalt binder released during mixing requires further study to ensure a consistent and reliable HMA job mix.

The finished pavement surface of all Test Sections appeared relatively smooth and well compacted, typical of a well placed and compacted conventional HMA pavement. Upon careful inspection, a few strands of roofing fragments could be observed and removed from the pavement surface. Initial findings indicate that a HMA job mix that includes up to 3 percent RAS by total weight can be successfully mixed, placed and compacted to the standards required of a conventional HMA mix.

7.2.4 Post-Construction Testing

Pavement Condition Survey

The post-construction survey conducted by WSDOT utilizing the distress data collection van revealed that the finished roadway surface is in near perfect visual condition with minutely recorded rutting. The roughness of the roadway measured below 95 in all Test Sections indicating a relatively smooth surface. However, Test Sections 3 and 4 rated about 20 points higher than Test Sections 1 and 2. This may be due to traveling over the existing Newhaukem Creek Bridge located in Test Section 3 and/or accelerating or decelerating during testing.

The survey will serve as a baseline for documenting deterioration of each roadway Test Section over time.

Skid Resistance Testing

Each Test Section recorded favorable skid resistance in both dry and wet conditions that would be commonly found on other similar King County Roadways. Initial test results indicate that incorporating a maximum of 3 percent RAS in the HMA job mix does not negatively impact nor significantly improve the skid resistance of the pavement surface.

Falling Weight Deflectometer Testing (FWD)

Analysis of data obtained from FWD testing has currently not been completed. A supplemental report will include the combined analysis of falling weight deflectometer data, current pavement thicknesses, subsurface conditions, and traffic analysis to predict the long-term performance of each Test Section. The supplemental report is scheduled for completion in March, 2010.

7.3 CONCLUSIONS

The initial use and performance of 3 percent RAS has had no impact, favorable or detrimental, when incorporated into the HMA job mix. Skid resistance testing shows that there was no noticeable change in resistance when including this material. Only a long-term study of the roadway will provide conclusive evidence of its performance. Further

testing, analysis, and documentation on the long-term performance of this roadway will continue for a minimum of three years to verify the impact on using RAS on public roadways in King County.

Respectfully Submitted,

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