WAPA
WISCONSIN ASPHALT PAVEMENT ASSOCIATION

LANNON STONE

Back 2 Basics: Aggregate

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Discussion Topics

- Introduction
- Aggregates in Context
- Exploration & Development
- Production
- Stockpiling & Transportation
- Future of HMA Aggregates
- Q&A

Introduction

- Picture Resume…

Introduction

Introduction – Lannon Stone

- History
  - Family firm established in 1967 to produce aggregates
  - 1970's – grew to 4 sites, hit by severe construction downturn
  - 1980's – Sales recovered and grew with the economy, 2nd generation full time in the business
  - 1990's – Sales continue to grow, servicing mostly housing construction, 2nd generation in management

Introduction – Lannon Stone

- Late 2000's… Great Recession
  - Very limited product offerings
  - No asphalt customers
  - No concrete customers
  - Little DOT exposure
  - We needed to change…

What did we do in response???

Introduction

Introduction

Introduction

Introduction

Introduction

Complete List of Perfect Plants:

How to Share "Expertise" with No Perfect Plants?

Aggregates

How to Lose a WAPA Guy – Tip #1

Get “sucked into the weeds”:

- Getting the job, cutting costs, increasing production, HR problems, getting a deal on equipment, Obama, etc…

Think Simply about Aggregates

- Good Properties
- Consistent Properties
- Clean Materials
- Dry Materials

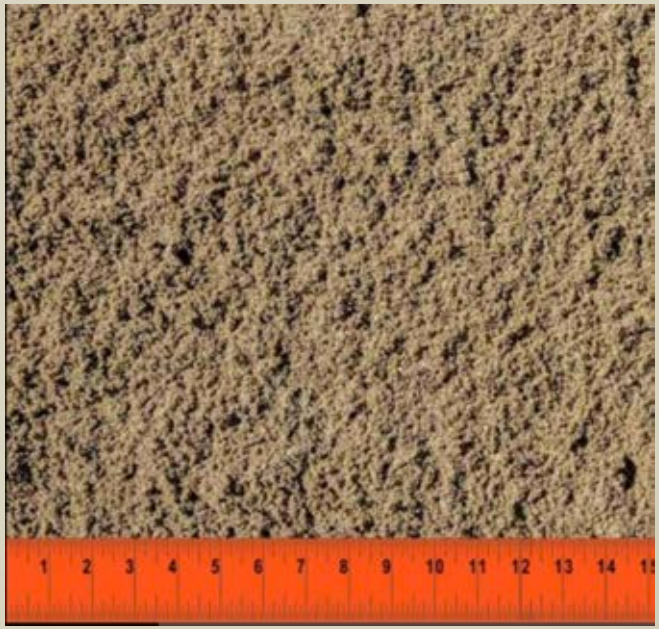
What is an Aggregate?

Wikipedia:

"broad category of coarse to medium grained particulate material used in construction, including sand, gravel, crushed stone, slag, recycled concrete and geosynthetic aggregates"

Coarse Aggregate

> #4 Mesh



Fine Aggregate

< #4 Mesh

Aggregates

2018 Data

	Crushed Stone	Sand & Gravel
Production (tons)	1.4 Billion	970 Million
Avg. Price ($/ton)	$11.90	$8.94
Geologic Source	68% Limestone & Dolomite 15% Granite 17% All Others	Glacial Deposits Weathering
Uses	75% Construction, mostly road 13% Cement 7% Lime 5% Other	44% Concrete 24% Road Conctruction 12% Asphalt 20% Fill & Other

Source: U.S. Geological Survey, Mineral Commodity Summaries, February 2019

Aggregates

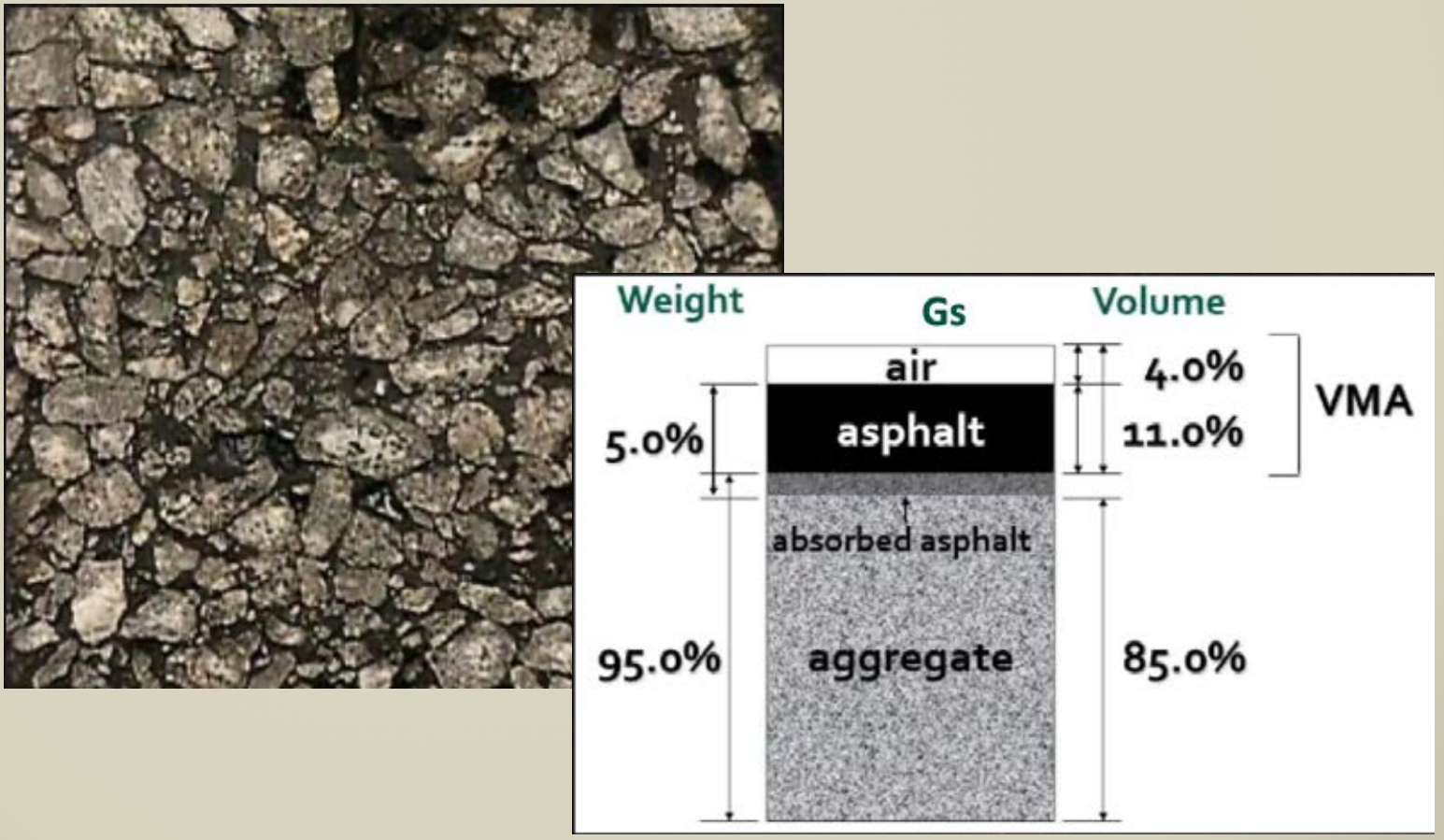
Types of Operations - ”Virgin” Aggregates

“Stone Quarry”

“Gravel Pit”

Aggregates

Main component of asphalt mixes



Exploration

How to Lose a WAPA Guy – Tip #2

"Hey – I got a *sweet* deal on a gravel pit!"

Exploration is the search for mineral resources with the hope that it will be an **economic** resource.

- Mineral properties
- Logistics considerations
- Permit feasibility
- Mining/processing considerations

Exploration

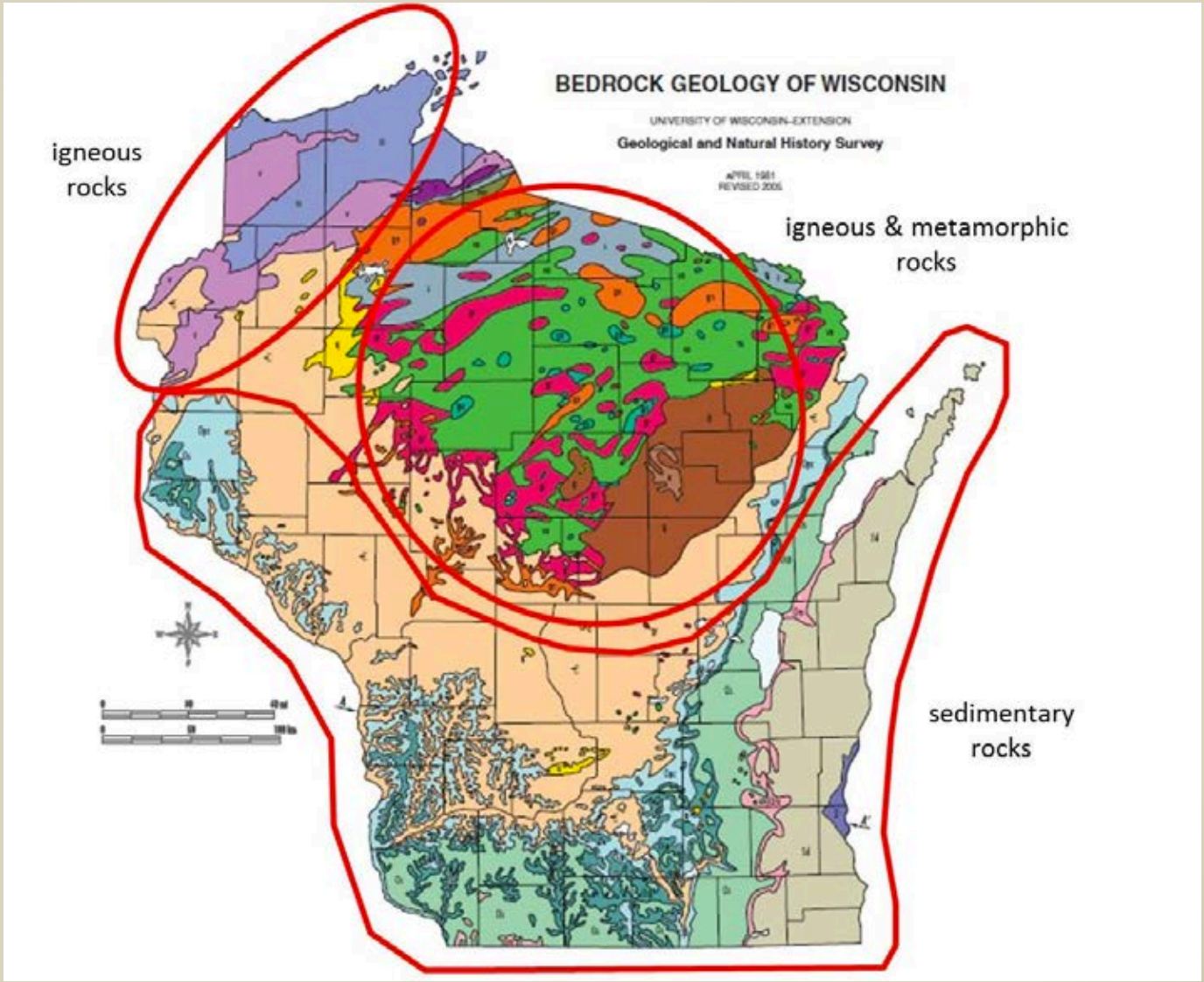
Source / Consensus Properties – WisDOT Specs

TABLE 460-2 MIXTURE REQUIREMENTS

Mixture type	LT	MT	HT	SMA
LA Wear (AASHTO T96)				
100 revolutions(max % loss)	13	13	13	13
500 revolutions(max % loss)	50	45	45	35
Soundness (AASHTO T104) (sodium sulfate, max % loss)	12	12	12	12
Freeze/Thaw (AASHTO T103) (specified counties, max % loss)	18	18	18	18
Fractured Faces (ASTM D5821 as modified in CMM 8-60) (one face/2 face, % by count)	65/___	75 / 60	98 / 90	100/90
Flat & Elongated (ASTM D4791) (max %, by weight)	5 (5:1 ratio)	5 (5:1 ratio)	5 (5:1 ratio)	20 (3:1 ratio)
Fine Aggregate Angularity (AASHTO T304, method A, min)	40	43	45	45
Sand Equivalency (AASHTO T176, min)	40	40	45	50
Clay Lumps and Friable Particle in Aggregate (AASHTO T112)	<= 1%	<= 1%	<= 1%	<= 1%
Plasticity Index of Material Added to Mix Design as Mineral Filler (AASHTO T89/90)	<= 4	<= 4	<= 4	<= 4

Also, Specific Gravity & Absorption

Exploration



Exploration

Geologic Variability - “The rock didn’t read the book”

Geologic variability is both problematic and inevitable, so a good dialogue between aggregate producers and customers is important.

Site Development

Design and Permitting is iterative and interdisciplinary

Politician

Lawyer

Engineer

Operations – Site Prep

Stripping = Exposing the ore

Typical activities:

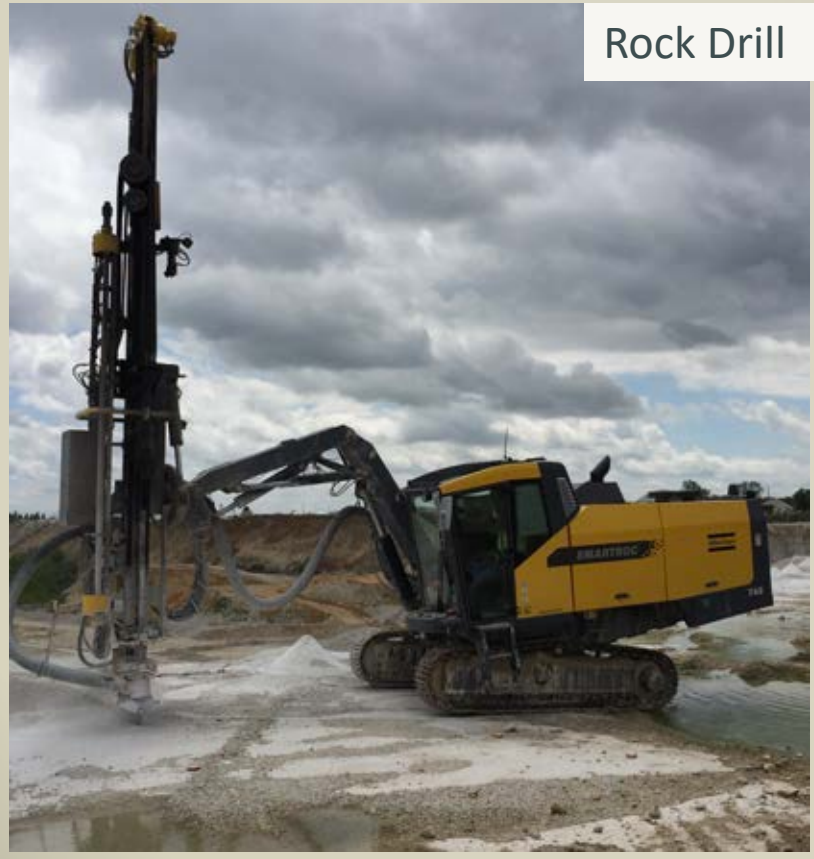
- Environmental Control
- Clearing & Grubbing
- Mass excavation
- Drill & Blast
- Restoration
- Blast prep

Screwing this up won't lose you a WAPA guy, but you will waste a lot of money.

Operations – Drill & Blast

Most rock can't be excavated directly – its too tough

Explosives must be placed into the rock and detonated to liberate the rock for processing



Rock Drill

Operations – Drill & Blast

How to Lose a WAPA Guy – Tip #3

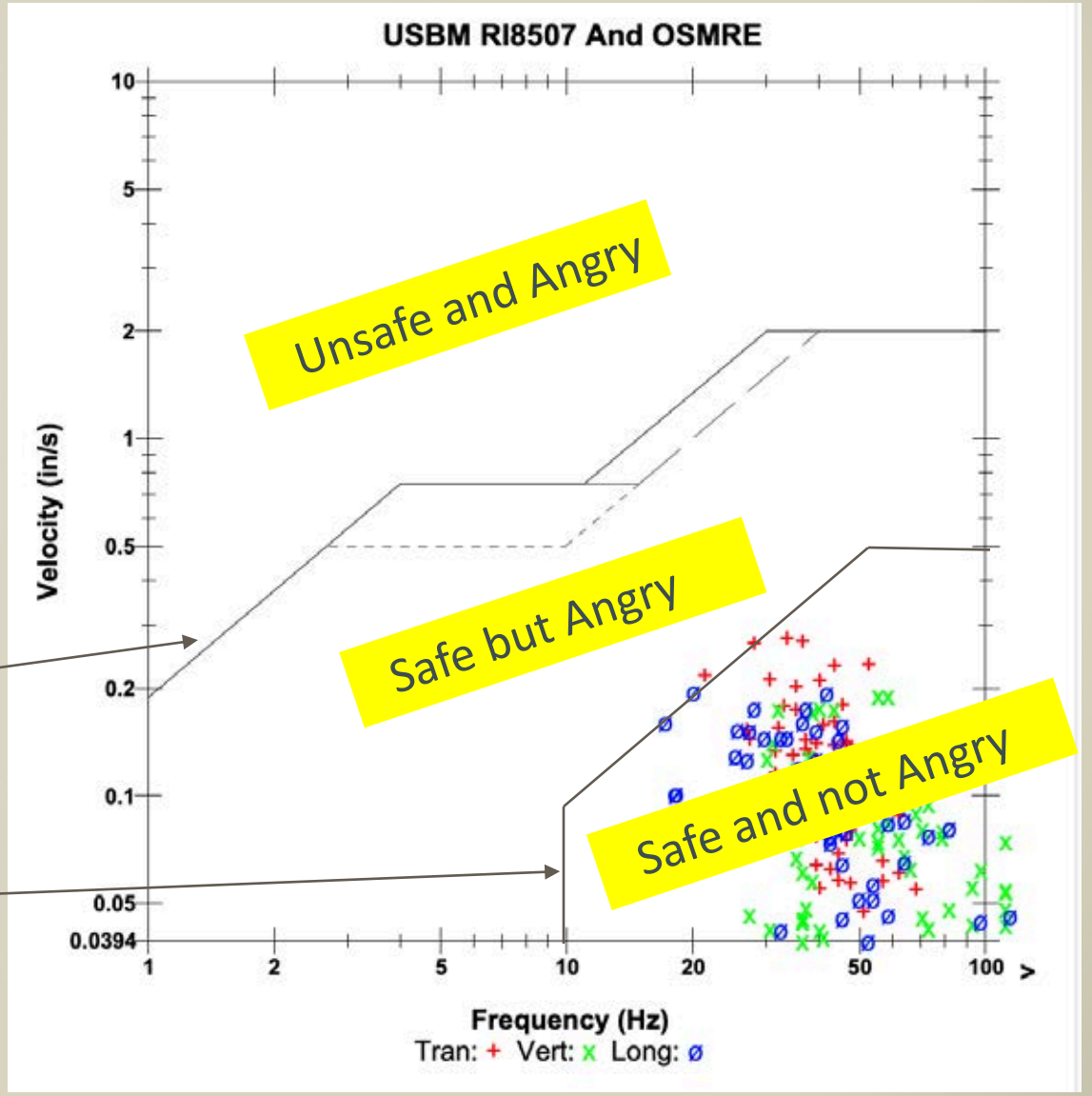
"Hey y'all – watch this!!"

Operations – Drill & Blast

Blasting is a design intensive operation

Operations – Drill & Blast

Beyond rock breakage, blasting results in a series of waves being sent into the ground around the quarry



"Z-Curve"

Modified "Z-Curve"

Operations – Load & Haul

Operations – Load & Haul

Material blending at the face can have very significant impacts on plant and product performance

Operations – Plant Design

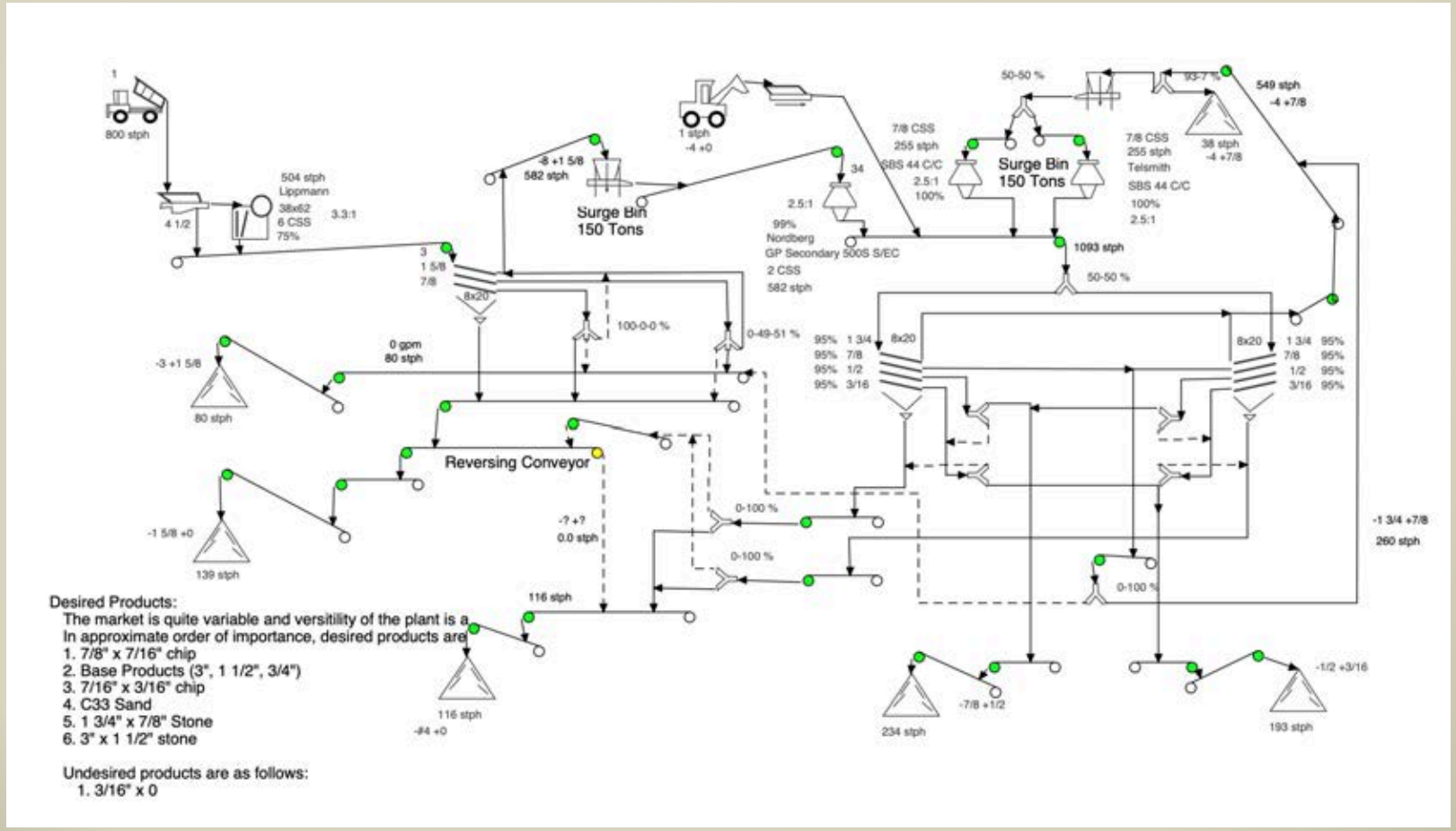
How to Lose a WAPA Guy – Tip #4

"Here's what the guys down the street did"

This is not the plant that another deposit needs

Operations – Plant Design

Plant design is an iterative process of analyzing alternative unit processes in a combination that will connect the deposit to the market in an economically optimal way



Plant Design → Product Design

Plant design is a process of product design

- Number of products
- Size of products
- Gradation of products
- Proportion of products
- Production flexibility
- Particle shape
- Stockpiling methods
- Washed / Dry Products
- Production rates
- Etc…

Operations – Crushing

The mechanical reduction of rock into finer particle sizes

4 Methods of Crushing

- Compression – pressing rock between 2 surfaces
- Impact – accelerating a rock to impact a single surface
- Attrition – rocks striking each other
- Shear – tearing rocks along weak planes

Typically used in Aggregates– Jaw, Gyratory, Cone, HSI, VSI

Less common types – Roll, Sizer, Hammermill, Ball/Rod/SAG Mill

Crushing - Jaw

Compression-type Primary Stage

Generally used on plants with less than 2,000tph capacity

Crushing - Gyratory

Compression-type

Primary or Secondary Stage

Generally used on plants with greater than 2,000tph capacity

Crushing - Cone

Compression-type

Secondary / Tertiary Stage

Crushing – Horizontal Shaft Impactor (HSI)

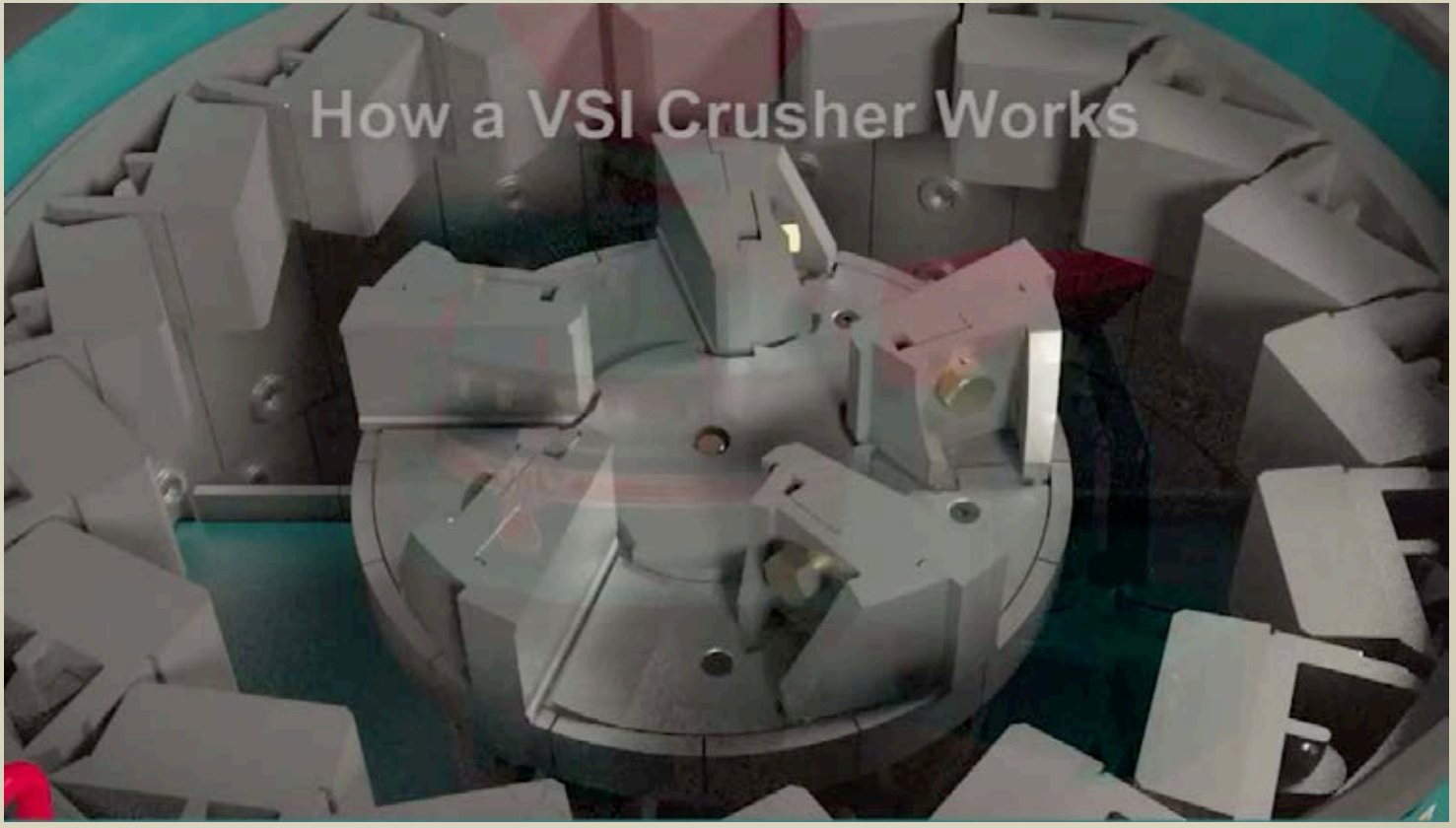
Impact-type

Primary / Secondary / Tertiary Stage

Crushing – Vertical Shaft Impactor (VSI)

Impact-type

Secondary / Tertiary Stage



Courtesy of CEMCO, Inc.

Operations – Crushing

How to Lose a WAPA Guy – Tip #5

Crusher Considerations

Crusher Selection and Optimization is a Relentless Process

- There are no firm rules, just principals to understand and questions to ask

Major Considerations

- Feed size, desired output gradation, material abrasiveness, production rate, control of feed, particle shape desired, deleterious materials present, etc.

Producer / consumer discussion is critical

Crusher Considerations

Unlike traditional manufacturing, it's not possible to make 1 size of material

- All crushers create a gradation of products

Size	% Passing
3"	100
2"	98
1"	65
3/4"	50
1/2"	32
3/8"	25
#4	13
#8	8
#16	5
#30	3.5
#100	2.2
#200	1.6

Typical circuit closed on 1"

Net Yield of 1 Stone:
= (65-25)/65
= 61.5%

Net Yield of 3/8" Chips:
= (25-13)/65
= 18.5%

Net Yield of Screenings:
= 13/65
= 20%

Crushing for Cubical Products

Items Affecting Particle Shape

- Reduction Ratio
  - Gradation of feed
  - Top size of rock in feed
  - Recirculating load
  - Crusher settings
- Geology (Type of rock)
- Type of crusher
  - Impact vs compact
- Operation of Crusher
  - Choke Fed
  - CSS
  - Speed

Again – no firm rules. LSP has VSI's crushing coarser than cones and cones making more cubical rock than VSI's

Operations - Screening

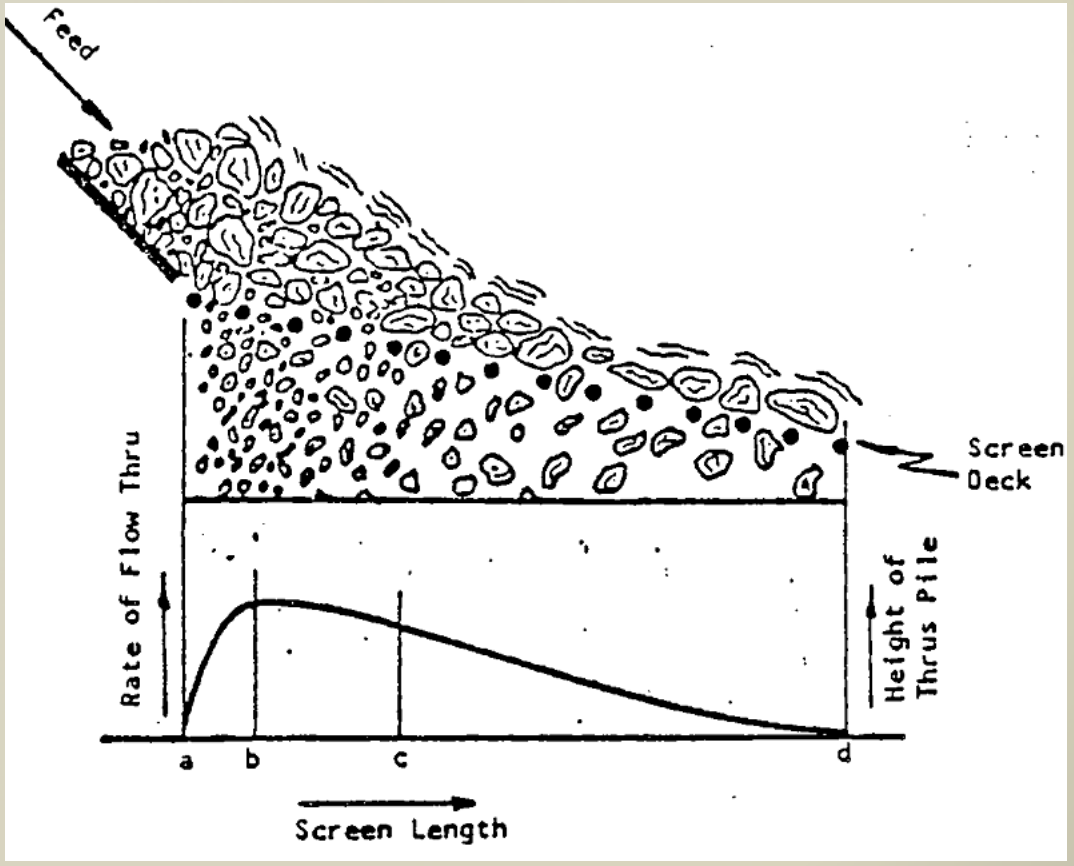
Dry screen

Operations – Screening

”The separation of aggregate particles into various sizes”

- Aggregates Handbook

Vibrating, mechanical screens are the most common



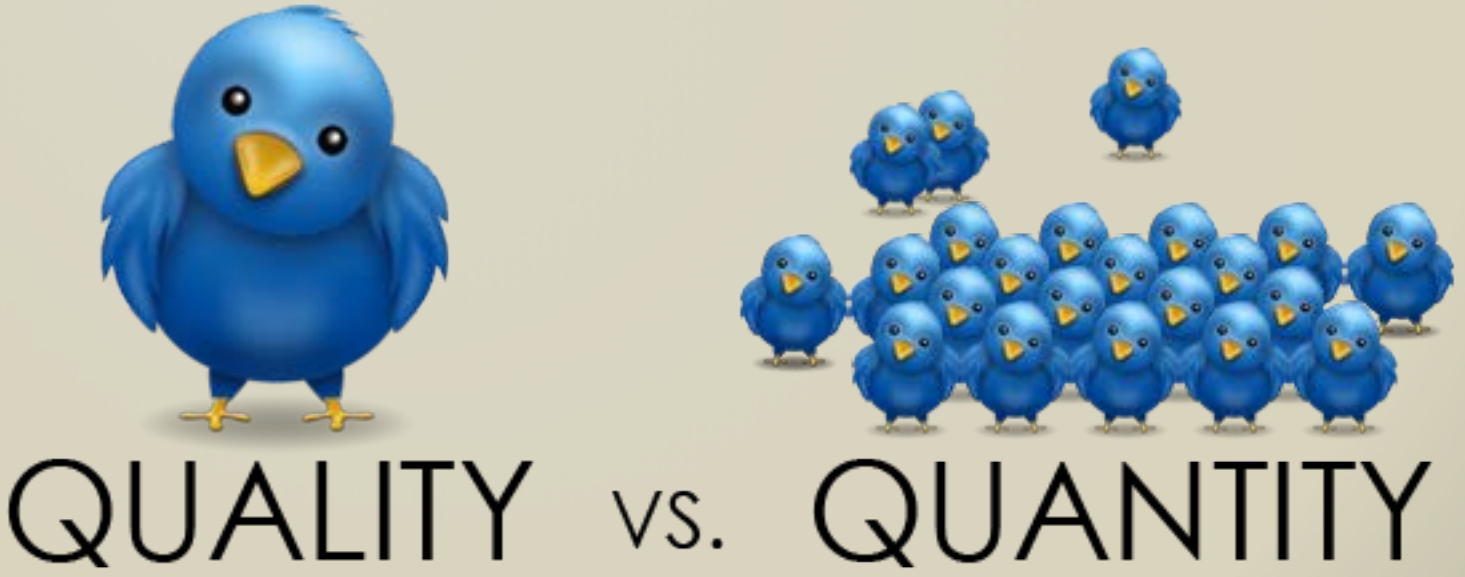
Screening

Horizontal, wet screen

Operations – Screening

How to Lose a WAPA Guy – Tip #6

"We set a record tonnage on our screen today!!"



Screening Considerations

A practical limit of 95% efficiency can be achieved:

- Adequate screen area and bed depth
  - Determined by VSMA calculation method
  - Circuit-driven and very expensive to fix…
- Speed / stroke of vibration profile
- Feed orientation
- Moisture control
- Media selection
- Maintenance

Operations – Washing

How to Lose a WAPA Guy – Tip #7

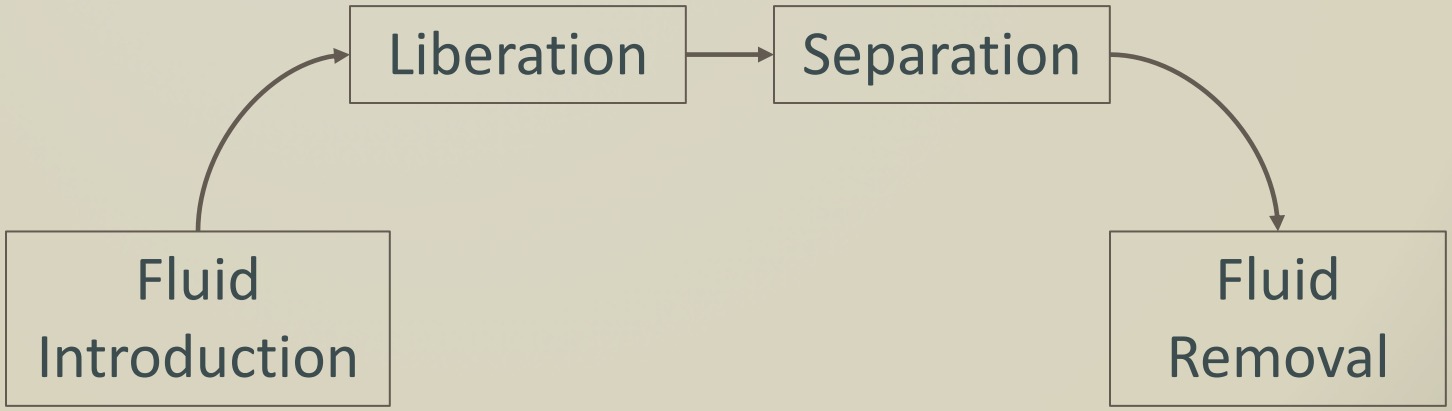
"Well – the other guy has a screw"

Operations – Washing

A fluid-based sizing method, typically used for cuts below #16

- Commonly water-based
- Can be air-based

Conceptual Model:



Washing - Liberation

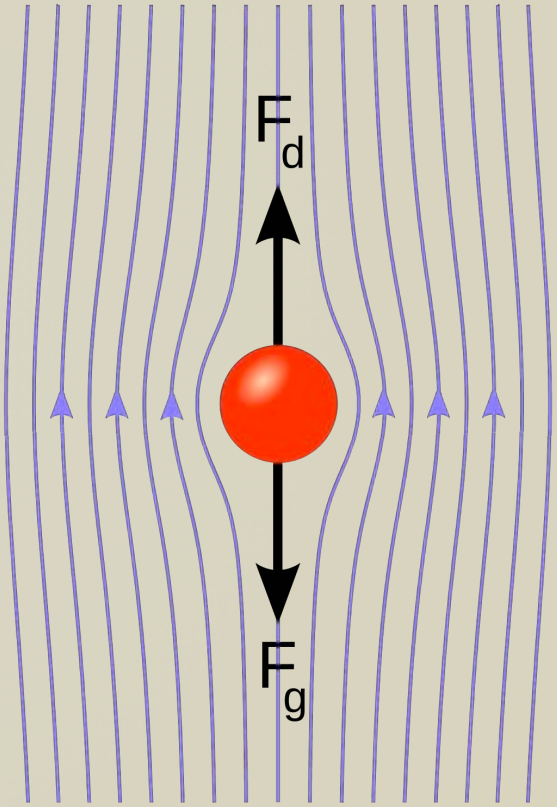
Ensuring that every particle is free from every other so that it can be separated by size.

Washing - Separation

Using Stoke's Law to exploit the difference between Drag force and Gravitational force

$F_d \sim r^2$

$F_g \sim r^3$



Changing the velocity of the fluid changes the size of particle that will settle – i.e. the cut point

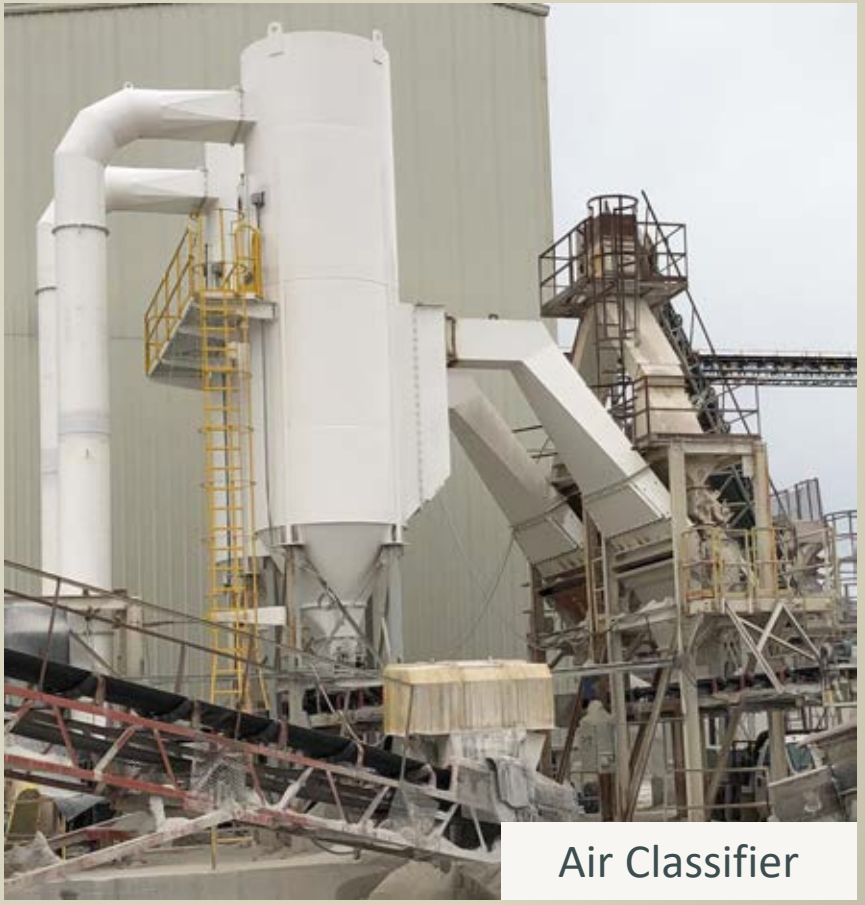
Washing - Separation

Hydrocyclone

Screw Washer

Washing - Separation

Classifying Tank



Air Classifier

Washing Considerations

- Each plant should be considered independently
- Solid and fluid flow rates affect each other
- Amount of liberation needed is site-specific
- Water accelerates wear of steel
- Water management is a significant concern
- Operational optimization is HUGE

- And…

Washing – Pond Fines

Stockpiling

Practical purpose – to manage the difference between production and sales

Stockpiling

Silo

Truck

Loader

Stockpiling

How to Lose a WAPA Guy – Tip #8

Use any stockpiling method – seriously, they are all bad

…but, some are less bad than others…

Stockpiling

Degradation

Stockpiling - Tips

- Understand the limitations of each stockpile method
- Determine a plan to manage segregation & degradation from the discharge conveyor to the asphalt plant feed belt
  - Think holistically
- Minimize the drop height of material
- Continually re-blend material – work the entire face
- Manage loader bucket contamination – fugitive material and scraping the ground
- Keep stockpiles separated
- Put your hands on the material – regular physical inspections

Sampling

Sampling accomplishes 2 basic goals:

- Confirms the suitability of the material for use as an aggregate
  - LA Wear, Freeze/Thaw, etc…
  - Location and type of sample method not as critical in most cases
  - Sample frequency ~annually
- Feedback mechanism for achieving consistent gradations at the asphalt plant
  - Location and type of sample method is very critical
  - Frequency ~daily

Belt Cut

Mini - Stockpile

Sampling

How to Lose a WAPA Guy – Tip #9

Sampling - Tips

- Very good and consistent sampling methods
  - WisDOT has an excellent class
- Test at multiple points
  - Belt, pit stockpile, plant stockpile
  - Understand where / how material can lose quality
- Lab procedures are just as important as sample taking
- Share the results widely
  - Pit loaders, plant operators, yard loaders, managers, engineers, qc techs all affect product quality
- Use belt sample results for immediate plant adjustment

Transportation

Source: Aggregate Handbook
Actual costs have large variability

- Aggregates are inexpensive, heavy materials
- Logistics significantly affect in-bin cost

~$0.18/ton/mile

~$0.05/ton/mile

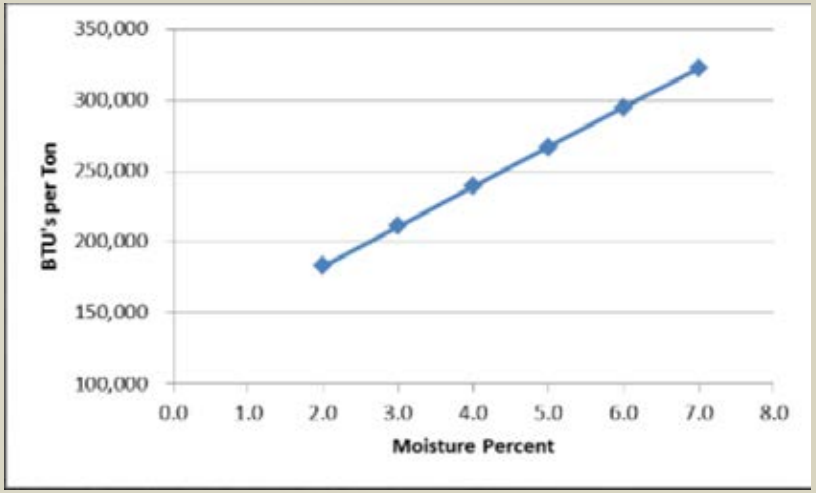
~$0.20/ton/mile

~$0.01/ton/mile

Moisture Management

Moisture management has 2 basic effects on HMA

1. High moisture content of aggregates increases plant costs
    1. Higher BTU load of the drum and slower plant TPH



2. Inconsistent moisture content results in loss of control of mix voids
    1. Asphalt plants create a product judged by VOLUMETRICS, but can only control WEIGHT
    2. Inconsistent moisture (and specific gravity, absorption) make it impossible to accurately make the conversion from weight to volume

Moisture Management

Coarse aggregates will retain less moisture than fine aggregates

This is especially true of material passing #200

p200

Water

Best Friends ☺

Moisture Management

Many different % Moisture Regimes within 1 Pile

Moisture Management

Strategies

- Aggregate processing and stockpiling techniques
  - Remove p200 from materials
  - Give time to dry / homogenize moisture content

Future of HMA Aggregates

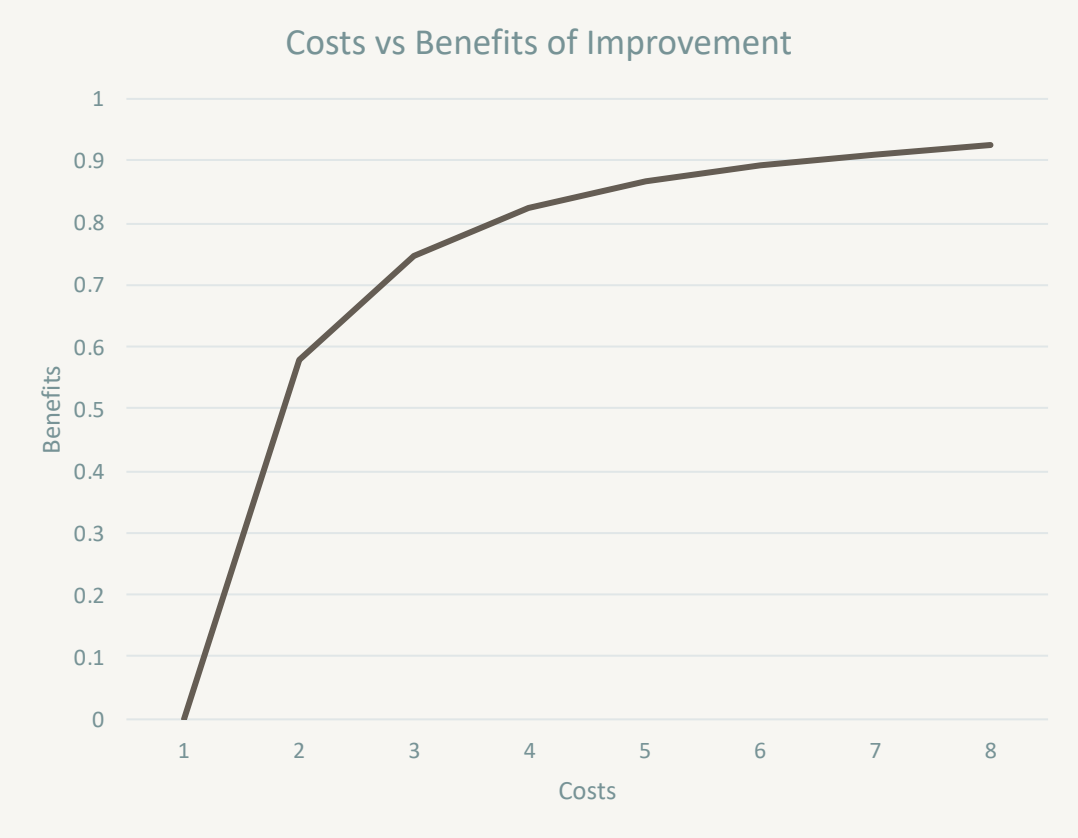
How to Lose a WAPA Guy – Tip #10

Learn too much from this presentation

The world is going to be different in 20 years,
we just don't know how

Future of HMA Aggregates

To make a difference, we need to be on the steep end of the curve



Future of HMA Aggregates

Some things will stay the same…

Aggregate should be/have:

- Good Properties
- Consistent Properties
- Clean Materials
- Dry Materials

Future of HMA Aggregates

How that is accomplished may change…

- Reorientation of the industry towards the long-term happiness of our stakeholders
- Access to raw materials will be dramatically more difficult to come by
- Under-engineered operations will have to change
- Structural changes to ownership / management of the industry
  - What are the benefits of vertical vs horizontal strategies
  - Skill / asset based organizational models may make vertical integration more difficult

Q&A