GREEN ASPHALT

WWW.GOGREENASPHALT.COM

Introduction

Jim McMurray

- Lifelong construction professional
- Small town - father was real estate developer
- NYC
- 1999 - Assistant Superintendent for heavy civil construction company (C.A.C. Industries)
- Underground utilities to final restoration
- 10 years as Superintendent before Green Asphalt

Agenda

Who is Green Asphalt?

Brief intro to Green Asphalt's timeline and goals.

Why RAP?

Overview of high-RAP benefits and RAP management.

Proven Performance

Overview of high-RAP mix designs and testing.

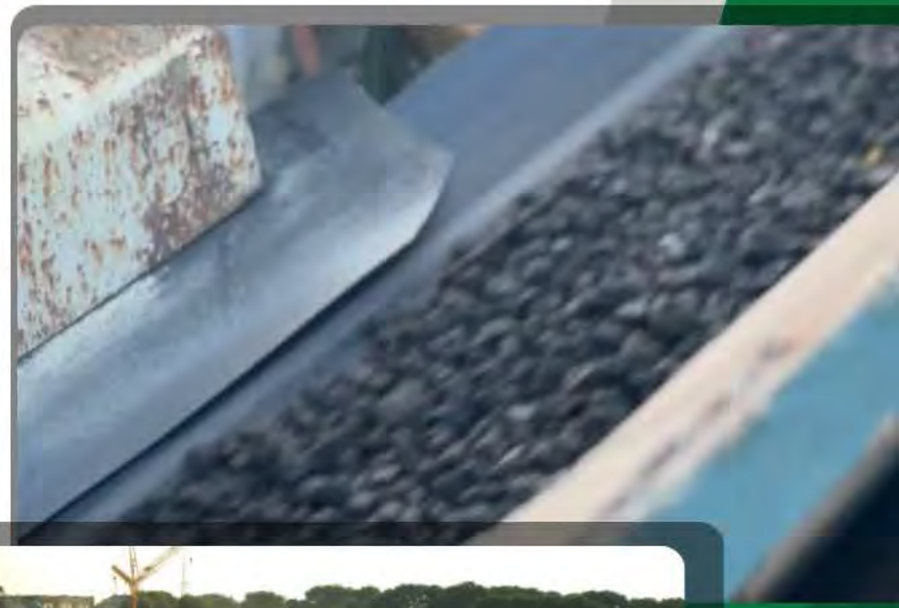
High-RAP Conversion Process

What does converting to a high-RAP plant look like? What are some common questions and concerns?

Who Is Green Asphalt?

About Green Asphalt

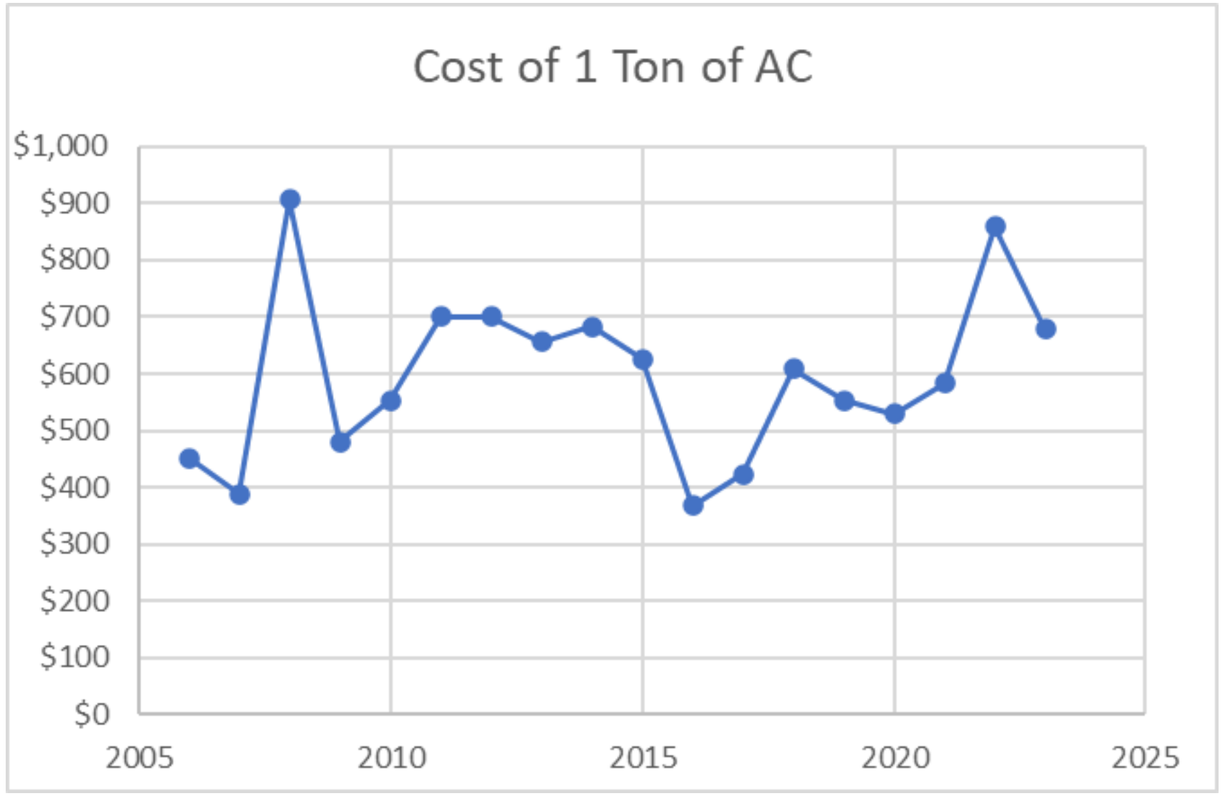
- Founded in 2009
- Asphalt Plant located in New York City
- Industry leader in 100% recycled asphalt pavement materials
- Nearly 2,000,000 tons of 100% RAP paved on NYC streets

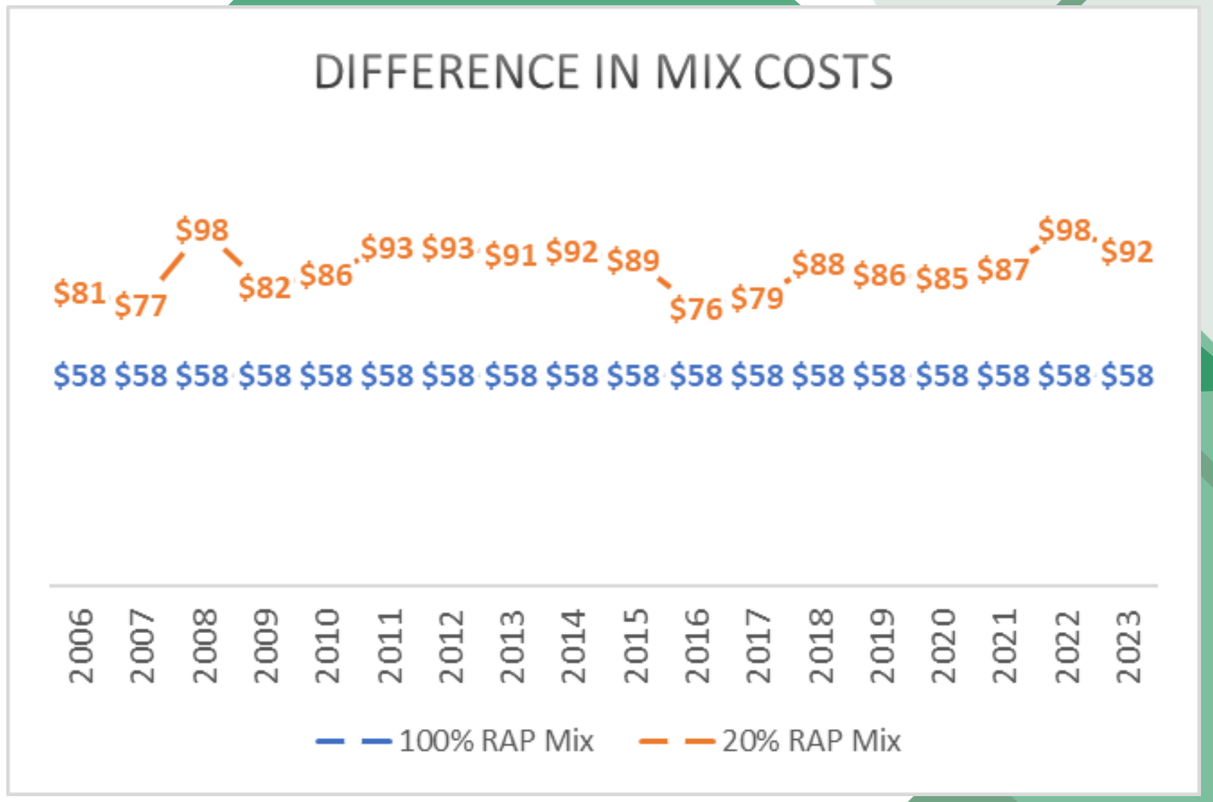


Timeline

- 2008 — Oil Market $ Increase
- 2009 — First Plant Built
- 2011 — First Ton of 100% RAP (Temp & Parking Lots)
- 2013 — Pothole Repair Contract
- 2013 — City DOT Pilot Project
- 2015 — NYSDOT Plant Approval
- 2016 — City approved for permanent paving
- 2019 — Patent on Air Filtration Unit
- 2021 — New Plant in LIC
- 2022 — EPD's Published
- 2023

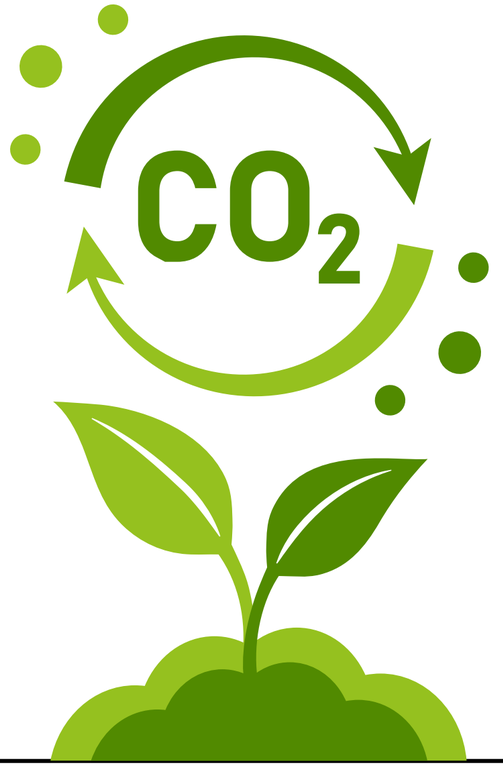
AC Cost


Cost of 1 Ton of AC
$1,000
$900
$800
$700
$600
$500
$400
$300
$200
$100
$0
2005
2010
2015
2020
2025


DIFFERENCE IN MIX COSTS
$81 $77 $98 $82 $86 $93 $93 $91 $92 $89 $76 $79 $88 $86 $85 $87 $98 $92
$58 $58 $58 $58 $58 $58 $58 $58 $58 $58 $58 $58 $58 $58 $58 $58 $58 $58
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023
100% RAP Mix
20% RAP Mix

RAP - The Solution!

- Biggest issue with heating up RAP is emissions
- Emissions control - key to 100% RAP
- 2009 - Started to develop technology for emissions control while setting up the first plant



Where to Start?

- NYC mixes 6F top and 3A binder
- needed to reverse engineer to make doable with 100% RAP
  - find a way to match gradations while meeting AC content
- goal: accomplish these mixes without using any virgin aggregate or asphalt cement

NYC Department of Design and Construction

QA & CONSTRUCTION SAFETY BUREAU

ASPHALT JOB MIX FORMULA SHEET - 3 RA BINDER MIX

PLANT NAME:	Green Asphalt Co LLC	MIX DESIGN DATE:	9/14/2023
NYSDOT FACILITY #:	H0385	PREPARED BY:	Matt Harrison
PLANT ADDRESS:	37-98 Railroad Avenue	COMPANY:	Green Asphalt Co LLC
	Long Island City, NY 11101	PLANT QC MGR:	Matt Harrison

Item	Supplier / Quarry		NYSDOT Source	High Friction	Agg. Blend %	Mix %	Lbs / Ton
						0.0%	0
						0.0%	0
						0.0%	0
						0.0%	0
				N/A		0.0%	0
				N/A		0.0%	0
Coarse RAP (1 1/2")	NYC DOT/DDC		N/A	Yes	78.0%	77.5%	1,549
	RAP % Asphalt:	4.4%		RAP AC		3.4%	68
				RAP Aggregate		74.1%	1,481
RAP Sand	NYC DOT/DDC		N/A	Yes	22.0%	21.8%	437
	RAP % Asphalt:	6.4%		RAP AC		1.4%	28
				RAP Aggregate		20.4%	409
Rejuvenating Oil	Grade:	Valero VP 165	SG (G_b):	1.034		0.7%	14
Total Asphalt Content (P_b):						5.5%	110
					100.0%	100.0%	2,000

Project No: Generic
"APPROVED"
NYC DDC - Office of Quality Assurance
Date: 12/12/23 Reviewed By: S.C.
LOG No: 2023-134

GreenAsphalt/3RA/Binder/Generic/NYCDDC/12/23/134 Expiration: 12/31/2025

QAACS SERIAL NUMBER & EXPIRATION DATE

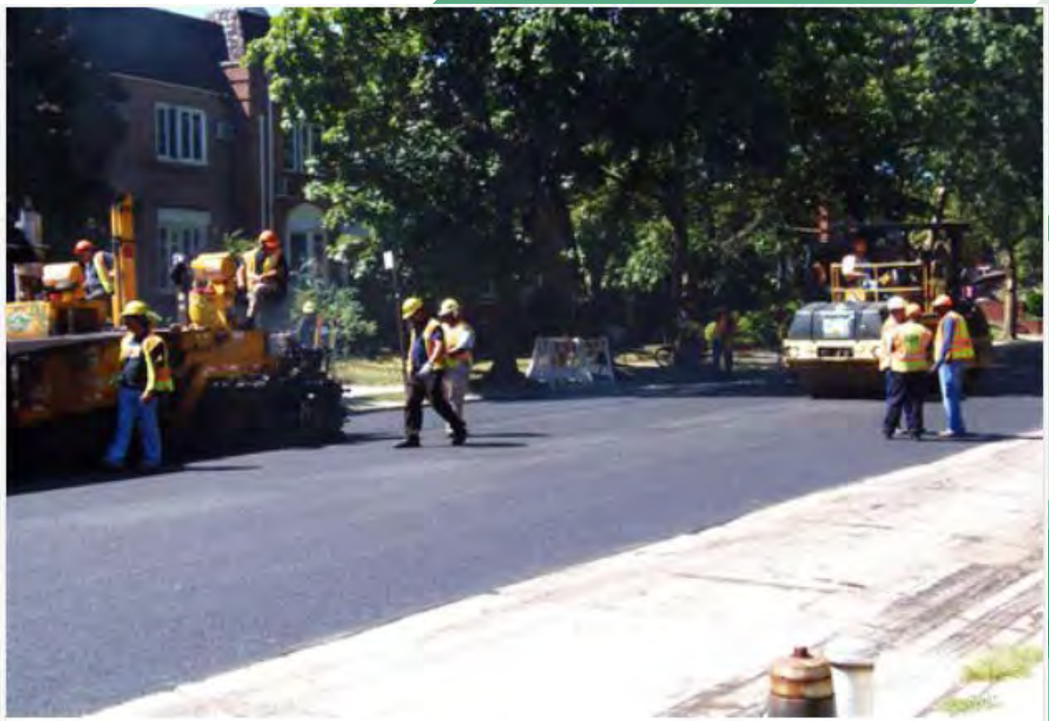
Sieve Size	1-1/2"	1"	3/4"	1/2"	1/4"	1/8"	# 20	# 40	# 80	# 200	P_b
Specification Limits	100-100	95-100	74-93	58-73	38-53	26-40	9-23	4-18	3-13	2-6	4-6
JMF Target	100	98	81	67	50	33	21	14	8	4	5.5
JMF Range	100-100	98-98	76-86	62-72	45-53	29-37	17-23	10-18	5-11	2-6	4.8-6

Temporary Asphalt

- 2011 - first ton of temp asphalt to parent company
- 3-6 months before removed & replaced
- utility trenches for gas, electric, communications, steam
- perfect testing ground for 100% RAP products at the beginning
- currently great testing ground for new rejuvenators
- lab tests plus performance testing on street

NYCDOT

- 2013 - NYCDOT pothole repair contract
- 2013 - NYCDOT pilot project - side by side with conventional 30% RAP



In the months ahead we'll see how the 100% RAP street surface holds up in NYC's harsh wear-and-tear use and weather conditions.

Stay tuned!

#streets #NYCstreets #New York City #NYC #DOT #NYCDOT #paving #resurfacing #Queens #KewGardens #green #recycled

8 notes Aug 14th, 2013

Agency Approvals

NEW YORK STATE OF OPPORTUNITY. Department of Transportation

2015

Plant Approval

NYC DDC Department of Design and Construction

2016

Mix Design Approval

2019 - Patented!

2021 - New Plant

Why RAP?

RAP vs. Conventional

Increasing RAP Content comes with sustainability, cost, and resource management benefits.

Emissions

Conventional asphalt embodies carbon from the quarrying and oil refining processes, as well as transport of those materials.

RAP Solution

RAP's lifecycle begins when it's brought to your plant for processing, removing emissions from quarrying, refining, and transporting.

AC Cost

AC is a variable commodity, the price of which greatly affects the cost to produce asphalt.

RAP Solution

Utilizing the existing AC in the RAP cuts down greatly, if not entirely, on the need to rely on virgin AC, steadying production price.

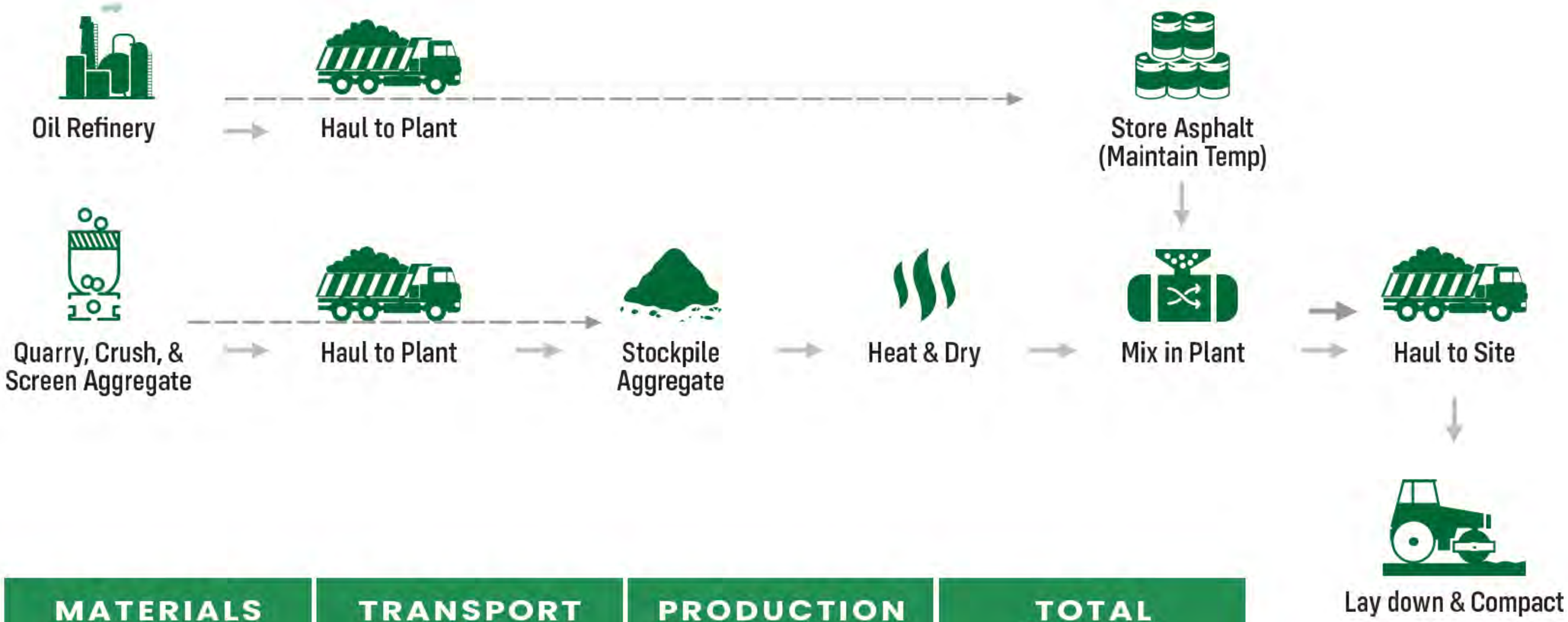
RAP Problems

RAP piles across the country can contain hundreds of thousands of pounds of an unused commodity.

RAP Solution

Utilizing this RAP frees up space and monetizes what would otherwise be considered waste.

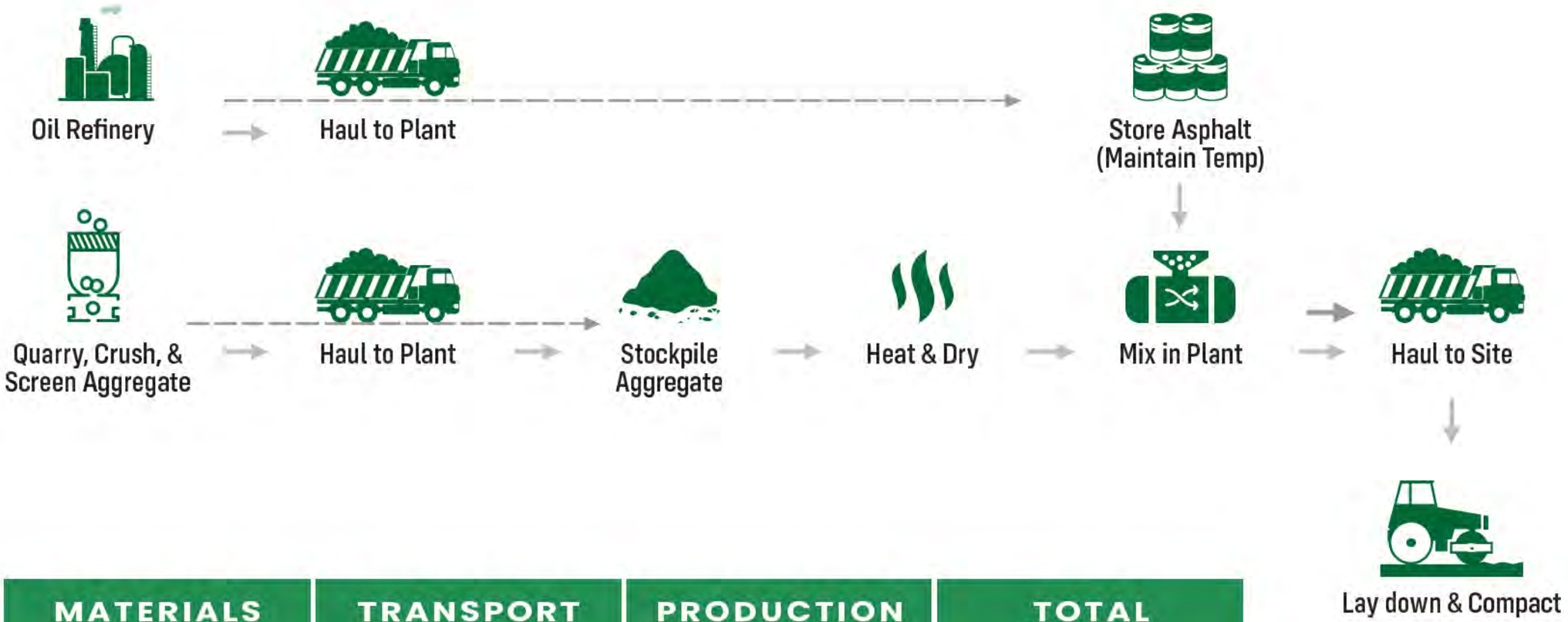
Emissions



MATERIALS (A1)	TRANSPORT (A2)	PRODUCTION (A3)	TOTAL (A1-A3)
35.42	12.27	21.54	69.22

* Numbers are for demonstration purposes only - not official calculations

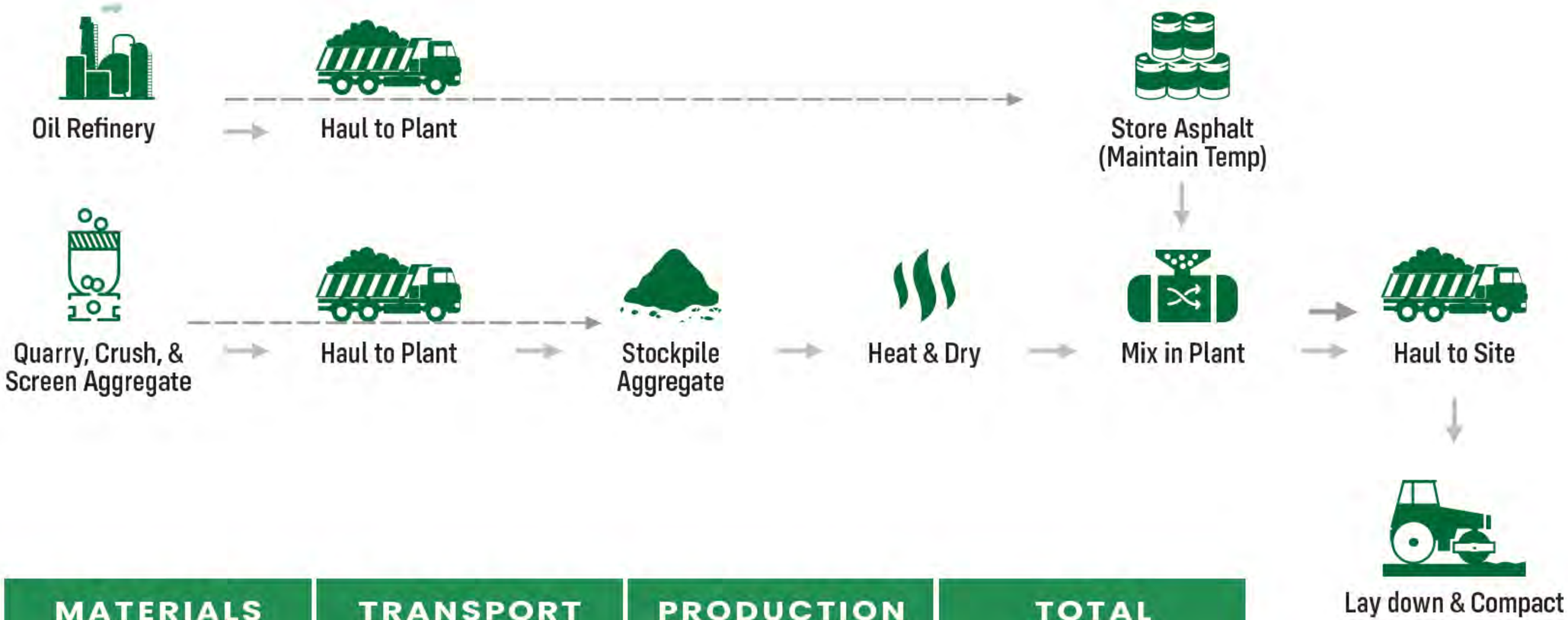
Emissions



MATERIALS (A1)	TRANSPORT (A2)	PRODUCTION (A3)	TOTAL (A1-A3)
0.78	12.27	21.54	34.59

* Numbers are for demonstration purposes only - not official calculations

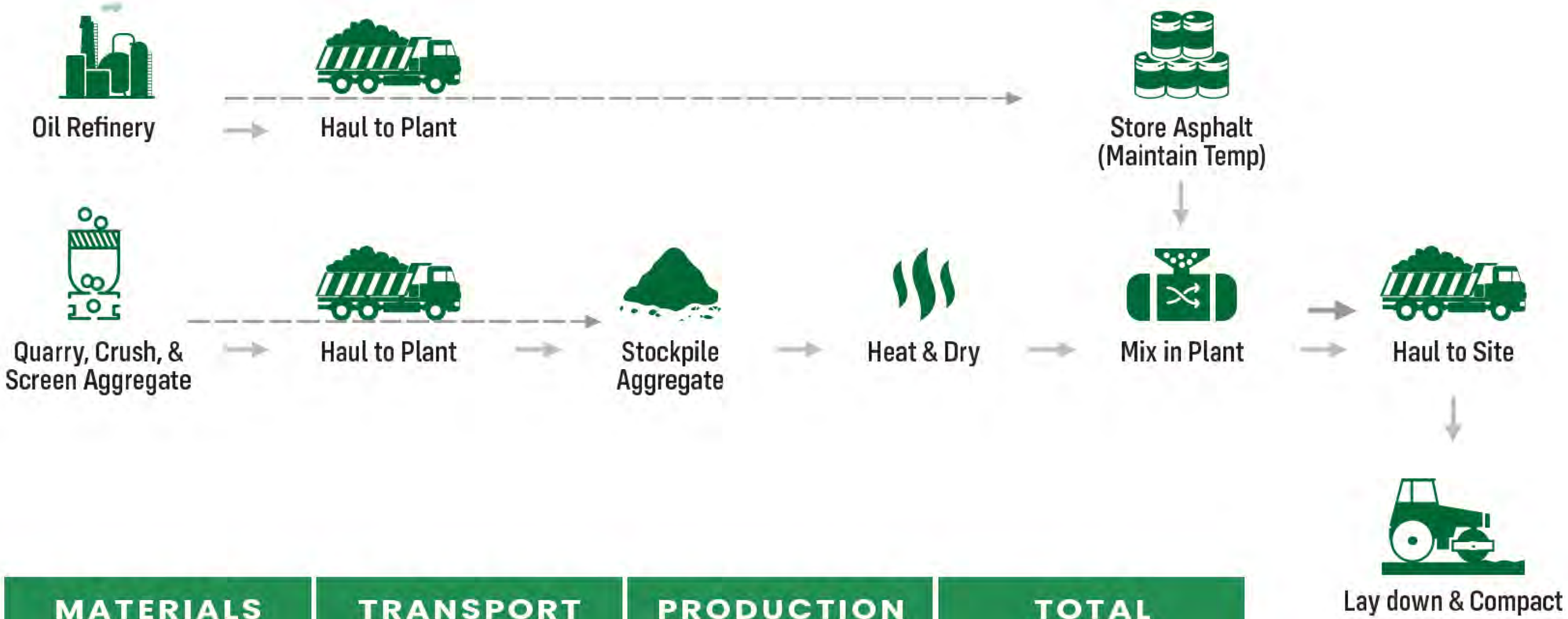
Emissions



MATERIALS (A1)	TRANSPORT (A2)	PRODUCTION (A3)	TOTAL (A1-A3)
0.78	0.11	21.54	22.42

* Numbers are for demonstration purposes only - not official calculations

Emissions



MATERIALS (A1)	TRANSPORT (A2)	PRODUCTION (A3)	TOTAL (A1-A3)
0.78	0.11	20.24	21.12

* Numbers are for demonstration purposes only - not official calculations

Emissions

Materials A1 – reduced by 80%-95%

Transport A2 – reduced by 80%-95%

Production A3 – reduced by 5%-10%

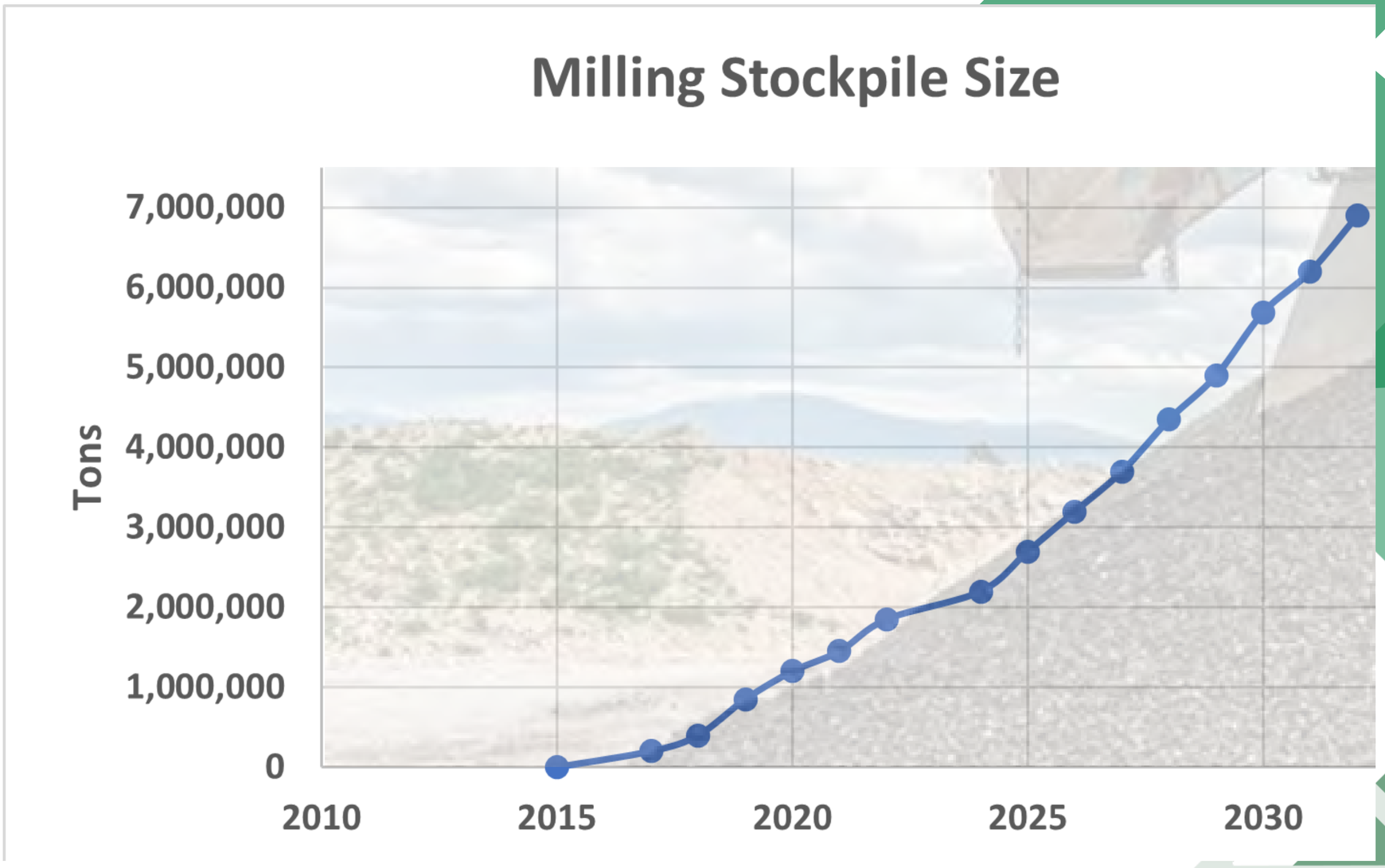
Total – reduced by 60%-70%

AC Cost

Example Project – Shore Road, Queens, NY

5444 Tons of Binder **1390 tons of Top**	**Asphalt cost with 100% RAP - $410,000** **Asphalt cost with Conventional Asphalt - $546,000**	**SAVINGS - $136,000**

RAP Problems



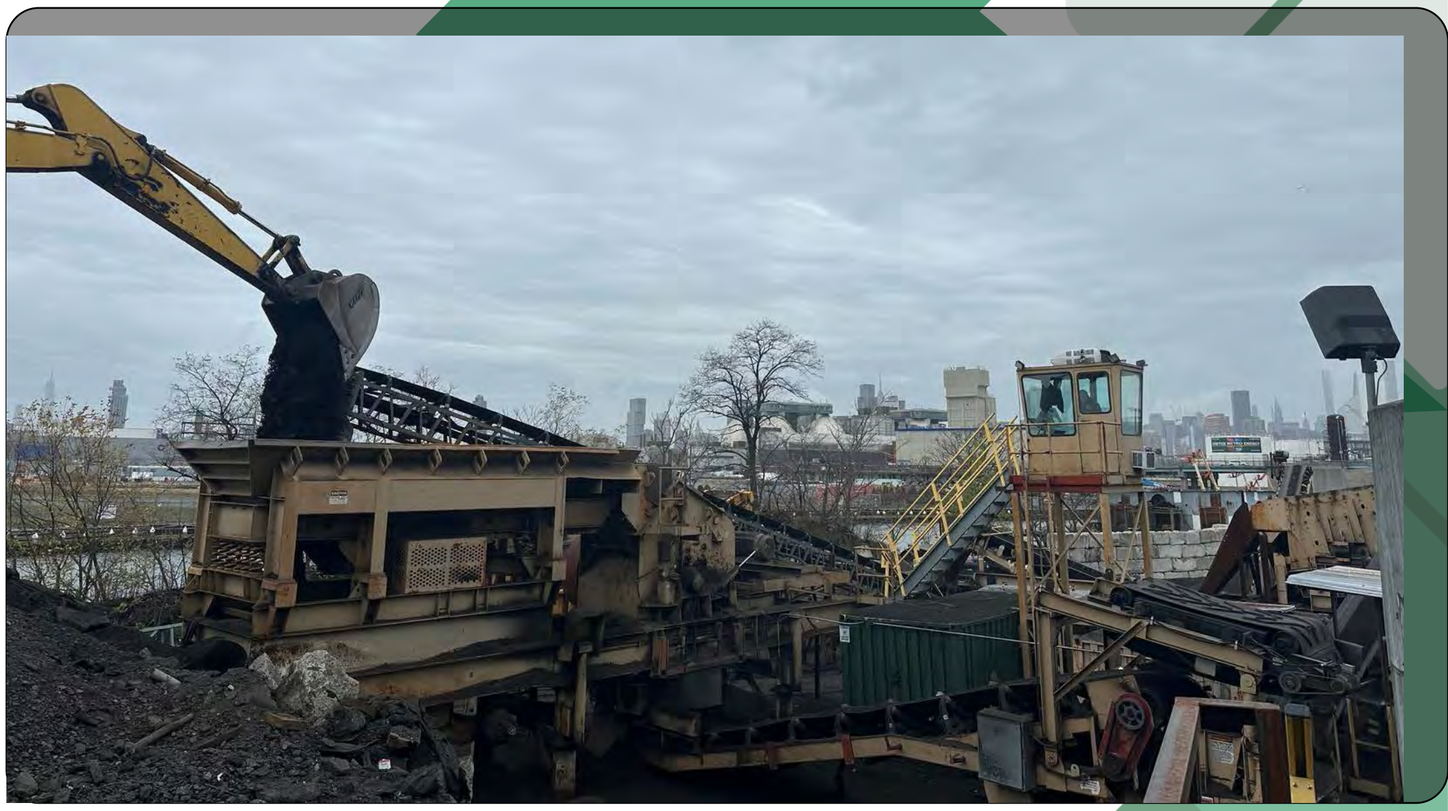
RAP Management

Goal - get all the AC you need from existing rap while meeting required gradations for target mix

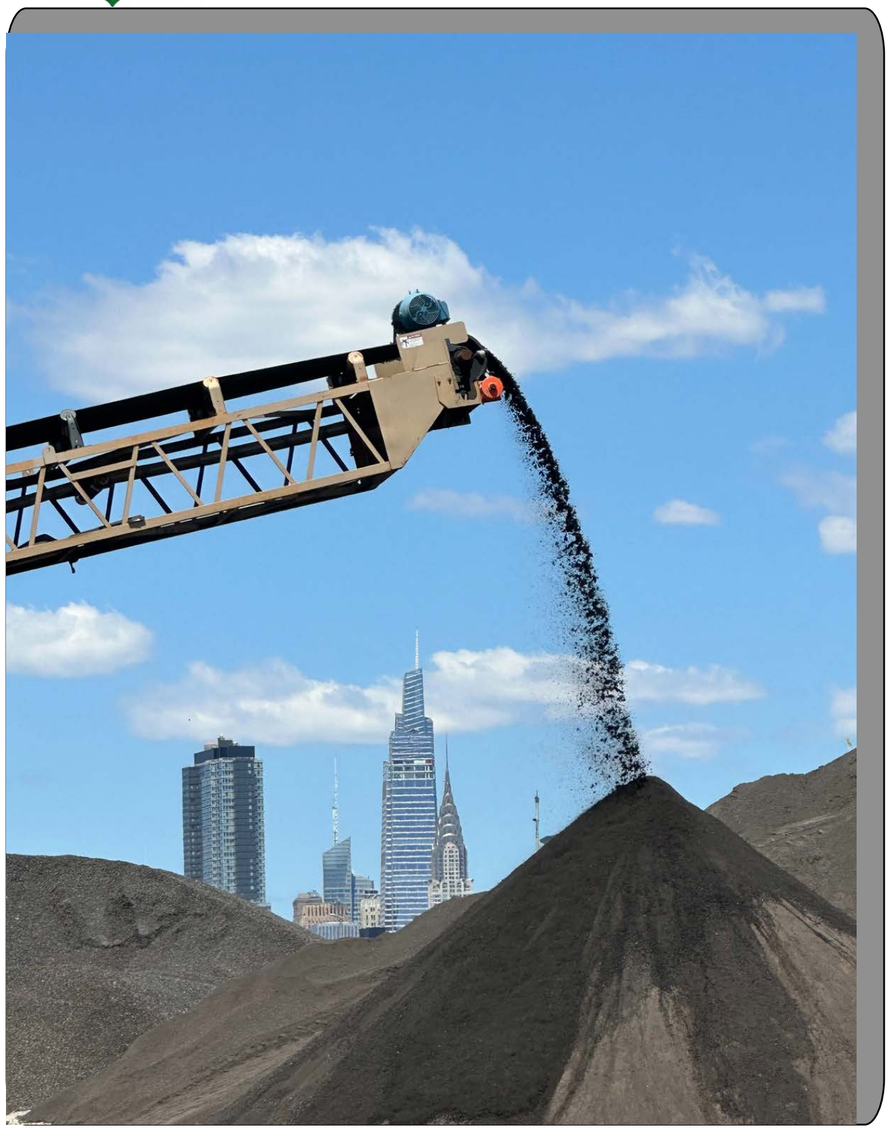
1) Pick target mixes you want to produce
2) “Reverse engineer” the mix to determine the proper sizes of aggregate you need to create
3) Initial tests of aggregate sizes in lab to ensure performance
4) Once sizes are determined, screens for processing equipment (crusher) can be ordered
5) Make adjustments as needed based on actual process results

RAP Piles -
You are now your own quarry!

- No longer only crushing to 1 size
- Closed-circuit impact crusher w/ triple deck screener
- Fractionate
- Need to follow best practices & strict QAQC guidelines to ensure consistency of your RAP aggregate



RAP Best Practices



- Crush and screen all RAP
- Screens depend on needed mixes
  - Back out of needed mixes to sizes
- Separate and stockpile RAP sizes
- Keep RAP covered and dry as much as possible

RAP QA/ QC

SAMPLING AND TESTING MATRIX

Test Property	Sample Location	Test Method	Minimum Frequency
Aggregate Gradation	MP401 Appendix E Test Method 3 or Haul Unit	AASHTO T 27	- 1 per sub-lot if QAF based on Gradation - 1 per lot if QAF based on Air Voids
Aggregate Moisture	MP401 Appendix E Test Method 3	AASHTO T 255	1 per lot
Wet Analysis Minus # 200 Sieve	Haul Unit	AASHTO T 11	1 per lot
Air Voids	Haul Unit	MM 5.16 and AASHTO T 269	1 per sub lot
Mix Moisture	Haul Unit	AASHTO T 329	1 per lot
Mix Temperature	Plant and Haul Vehicle	N/A	2 per sub lot
PG Binder Content	Haul Unit	Automation and Ignition Oven (NY 400-13C)	1 per sub lot
RAP Binder Content	Representative Sample	Ignition Oven (NY400-13C)	2 per week
RAP Gradation	MP401 Appendix E	AASHTO T 27 AASHTO T 11	2 per week
RAP Moisture		Test Method 2	1 per day
Asphalt Binder Sampling		Test Method 1	1 per day
Friction Aggregate	MM 28	MM 28	As outlined in MM 28
Dust/Binder Ratio	Haul Unit	AASHTO R35-04	Recommended

RAP QA/ QC

Gradation Examples

Green Asphalt Average Gradation		
Stockpile:	**RAP Sand**	NYC DOT - BK 2024
RAP Liquid AC:	**6.41%**	
Sieve Specification:	NYC DDC	
SIEVE SIZE	**PERCENT RETAINED**	**PERCENT PASSING**
1/2"	0.00	100.00
1/4"	2.02	97.98
1/8"	26.29	71.68
NO. 20	30.44	41.25
NO. 40	11.71	29.54
NO. 80	13.70	15.84
NO. 200	8.69	7.15
PAN	7.15	0.00

Green Asphalt Average Gradation		
Stockpile:	**3/8" RAP STONE**	
RAP Liquid AC:	**3.74%**	
Sieve Specification:	NYC DDC	
SIEVE SIZE	**PERCENT RETAINED**	**PERCENT PASSING**
1/2"	1.34	98.66
1/4"	65.72	32.94
1/8"	11.41	21.54
NO. 20	5.60	15.93
NO. 40	2.82	13.11
NO. 80	5.11	8.00
NO. 200	4.48	3.52
PAN	3.52	0.00

RAP QA/ QC

Asphalt Extraction Examples

REPORT ON SAMPLE(S) OF PERFORMANCE GRADED BINDER		DLSI
DLSI Internal ID		
Material Supplier	GREEN ASPHALT	
Supplier ID		
Ref #		3RA-424
Date Tested		04/10/23
Batch #		
PG Grade		PG 76-22
Continuous PG Grade		PG 77.2-22.6

REPORT ON SAMPLE(S) OF PERFORMANCE GRADED BINDER		DLSI
DLSI Internal ID		
Material Supplier	GREEN ASPHALT	
Supplier ID		
Ref #		6FRA-425
Date Tested		04/10/23
Batch #		
PG Grade		PG 76-16
Continuous PG Grade		PG 80.6-19.8

Proven Performance

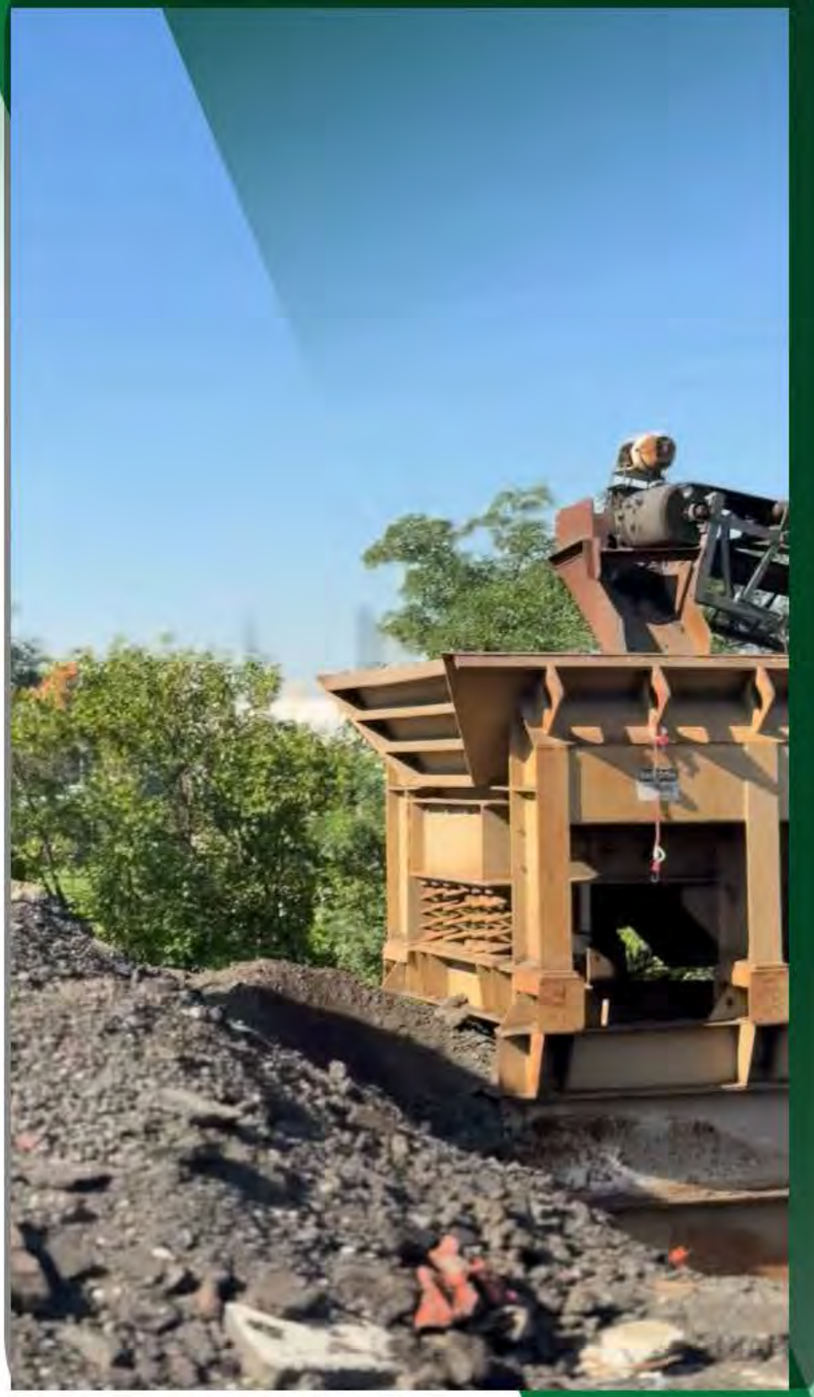
Proven Performance

- Nearly 2,000,000 tons of 100% RAP mix on NYC Streets & 3rd party logistics centers
- Thousands of jobs paved with 100% RAP
- More than 75 loyal & consistent customers
- Oldest job - 11 years
- High profile job:
  - Pelham Parkway, 7000 tons
  - Bus route, major thoroughfare, semi-arterial roadway

Mix Designs

NYC Top & Binder mix achieved with 3 sizes:

- **5/16" minus - “RAP Sand”**
  - Average AC Content - **6.4%**
- **1/2" minus - “3/8” RAP Stone”**
  - Average AC Content - **4.1%**
- **1" minus - “3/4” RAP Stone”**
  - Average AC Content - **4.4%**



Mix Designs

NYC 6F Top mix:

35.6% 5/16" minus (RAP sand)
6.4% AC
64.4% 1/2" minus (3/8" RAP stone)
4.1% AC

0.5% Rejuvenator

5.4% AC in final mix

PLANT NAME:	Green Asphalt Co LLC				MIX DESIGN DATE:	9/19/2023	
NYSDOT FACILITY #:	H0385				PREPARED BY:	Matt Harrison	
PLANT ADDRESS:	37-98 Railroad Avenue				COMPANY:	Green Asphalt Co LLC	
	Long Island City, NY 11101				PLANT QC MGR:	Matt Harrison	

Item	Supplier / Quarry		NYSDOT Source	High Friction	Agg. Blend %	Mix %	Lbs / Ton
						0.0%	0
						0.0%	0
						0.0%	0
						0.0%	0
				N/A		0.0%	0
				N/A		0.0%	0
Rap 6F Stone (-5/8)	NYC DOT/DDC		N/A	Yes	64.4%	64.1%	1,282
	RAP % Asphalt:	4.1%		RAP AC		2.6%	52
All RAP to be from Municipal Sources - Aggregates from State Quarries				RAP Aggregate		61.5%	1,230
RAP Sand	NYC DOT/DDC		N/A	Yes	35.6%	35.4%	708
	RAP % Asphalt:	6.4%		RAP AC		2.3%	46
All RAP to be from Municipal Sources - Aggregates from State Quarries				RAP Aggregate		33.1%	662
Rejuvenating Oil	Grade:	Valero VP 165	SG (G_b):	0.93		0.5%	10
Total Asphalt Content (P_b):						5.4%	108
					100.0%	100.0%	2,000

Project No: Generic
"APPROVED"
NYC DDC - Office of Quality Assurance
Date: 12/12/23 Reviewed By: S.C.
LOG No: 2023-131
QA&CS APPROVAL STAMP

GreenAsphalt/6FRA/Top/Generic/NYCDDC/12/23/131 Expiration: 12/31/2025
QA&CS SERIAL NUMBER & EXPIRATION DATE

Mix Designs

NYC 3A Binder mix:

22.0% 5/16" minus (RAP sand)
6.4% AC
78.0% 1" minus (3/4" RAP stone)
4.4% AC

0.7% Rejuvenator

5.5% AC in final mix

PLANT NAME:	Green Asphalt Co LLC	MIX DESIGN DATE:	9/14/2023
NYSDOT FACILITY #:	H0385	PREPARED BY:	Matt Harrison
PLANT ADDRESS:	37-98 Railroad Avenue	COMPANY:	Green Asphalt Co LLC
	Long Island City, NY 11101	PLANT QC MGR:	Matt Harrison

Item	Supplier / Quarry	NYSDOT Source	High Friction	Agg. Blend %	Mix %	Lbs / Ton
					0.0%	0
					0.0%	0
					0.0%	0
					0.0%	0
			N/A		0.0%	0
			N/A		0.0%	0
Coarse RAP (1 1/2")	NYC DOT/DDC	N/A	Yes	78.0%	77.5%	1,549
	RAP % Asphalt: 4.4%		RAP AC		3.4%	68
All RAP to be from Municipal Sources - Aggregates from State Quarries			RAP Aggregate		74.1%	1,481
RAP Sand	NYC DOT/DDC	N/A	Yes	22.0%	21.8%	437
	RAP % Asphalt: 6.4%		RAP AC		1.4%	28
All RAP to be from Municipal Sources - Aggregates from State Quarries			RAP Aggregate		20.4%	409
Rejuvenating Oil	Grade: Valero VP 165	SG (G_b):	1.034		0.7%	14
Total Asphalt Content (P_b):					5.5%	110
				100.0%	100.0%	2,000

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QA&CS SERIAL NUMBER & EXPIRATION DATE

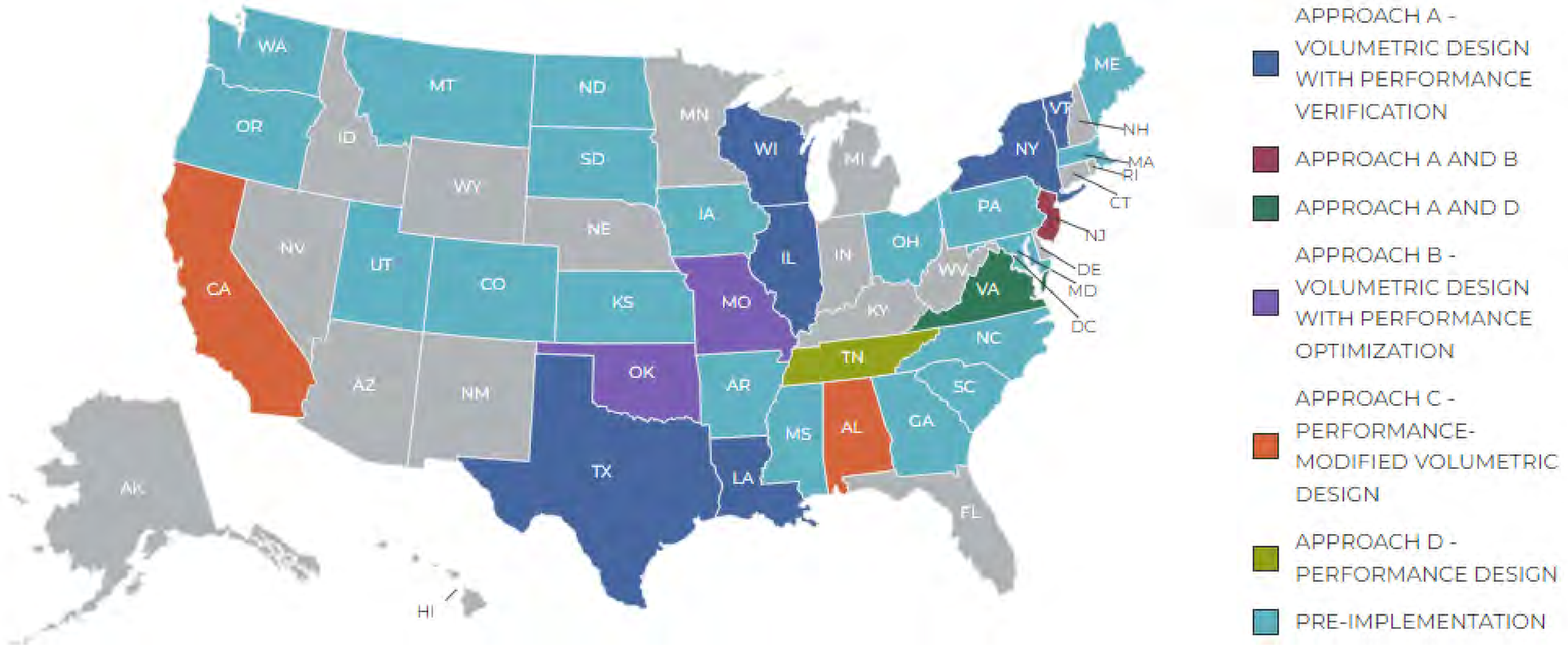
Balanced Mix Design

“Asphalt mix design using performance tests on appropriately conditioned specimens that address multiple modes of distress taking into consideration mix aging, traffic, climate and location within the pavement structure.”
-Federal Highway Administration

Essentially:
Performance Based Mixes

Balanced Mix Design

FILTER BY: BMD APPROACH | RUTTING TEST | CRACKING TEST



Balanced Mix Design

New York City Requirements:

TABLE 3.09-I - PERFORMANCE TESTING CRITERIA

Test Methods	Criteria	Min. Design Value	Max. COV[1]
RUTTING TESTS			
AASHTO T324 Hamburg Wheel-Track Test	Rut Depth	12.5 mm	N/A
ASTM D6931 Indirect Tensile Strength (IDT) Test	IDT Strength	30 psi	≤15
CRACKING TESTS			
AASHTO T 393 SCB Flexibility Index (FI) Test	Flexibility Index	8	≤40
ASTM D8225 CT Index Test	CT Index	135	≤25

Note 1: COV = Coefficient of Variation, defined per ASTM E177.

Balanced Mix Design

New York City Requirements:

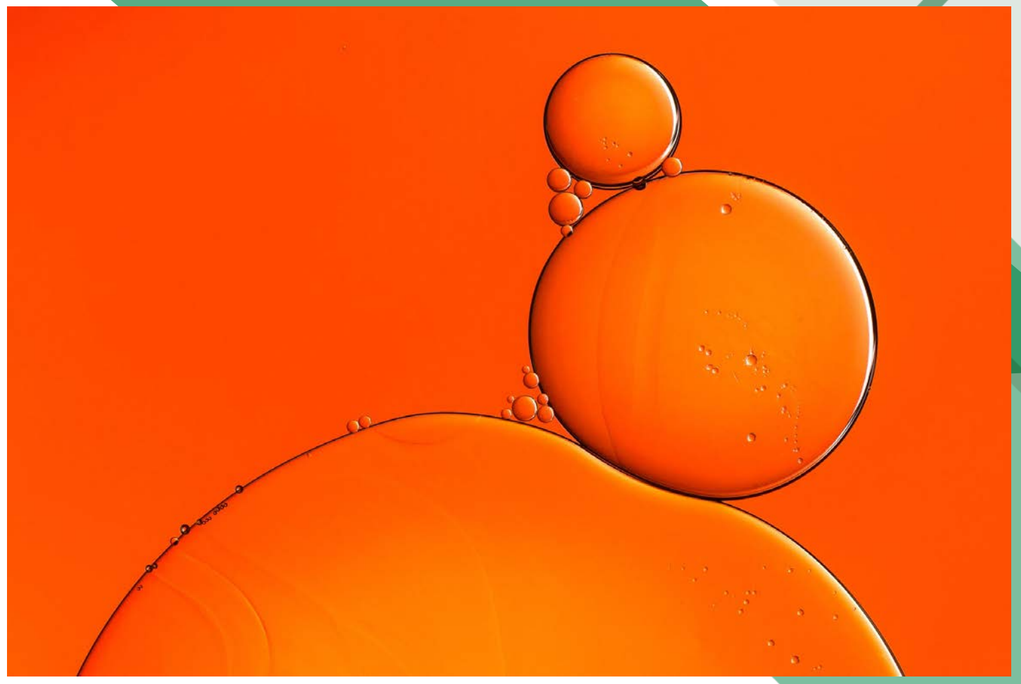
PERIODIC PERFORMANCE TESTING FREQUENCY

Mix Design RAP%	Periodic Testing Frequency		
	Cracking (SCB FI, *or* CT Index)	Rutting (IDT)	Rutting (Hamburg)
RAP% ≤ 40%	Weekly	Weekly	6 months
40% < RAP%	Every third day	Every third day	3 months

Rejuvenators

Rejuvenators play a large role in the performance of high-recycled content mixes.

- Parrafin
- Tall
- Soy
- Petroleum
- Recycled vegetable oil
- Recycled motor oil



Balanced Mix Design

Hamburg Wheel-Track Testing of Compacted HMA
Test Method AASHTO T 324-18

Client:	Green Asphalt	**Project**	Bayside Cores
Material:	Asphalt Cores	**Project Number:**	230233
Source:	Bayside Cores	**Lab Number:**	23-0344C
Date Sampled:	2/14/2023	**Sampled By:**	Client
Date Tested:	3/30/2023	**Tested By:**	John Brinsfield

WMA Add/Dosage	Not Provided	**Anti-Strip/Dosage**	Not Provided
RAP %	Not Provided	**Aggregate Source**	Not Provided
Mix Production	Fabricated by Client	**Test Temperature**	45
Mix Compaction	Fabricated by Client		

	LEFT WHEEL		RIGHT WHEEL	
Sample Number	1	2	1	2
Diameter	143.0	143.0	143.0	143.0
Thickness	60.0	60.0	60.0	60.0
Bulk SpGr	2.478	2.408	2.375	2.316
Max SpGr	2.572	2.572	2.572	2.572
% Air Void	3.65	6.38	7.66	9.95
Max Impression (mm)	5.86		7.64	
PassNo./Point	19880 / 3		20000 / 7	
Creep Slope	-0.000215866		-0.000356129	
Stripping Inflection Point	None		None	
Fail Depth	N/A		N/A	
Pass?	N/A		N/A	

Balanced Mix Design

Green Asphalt Hamburg Results:

2.68	9.44
2.08	7.7
5.86	2.42
7.64	2.53

State Requirements:

State	Maximum Rut Depth for HWTT (mm)
California	12.5
Georgia	12.5
Illinois	12.5
Louisiana	10
Maine	12.5
Massachusetts	12.5
Missouri	12.5
Montana	13
New York	12.5
Oklahoma	12.5
Pennsylvania	12.5
Tennessee	12.5
Texas	12.5
Utah	10
Vermont	10
Washington	10
Wisconsin	12.5

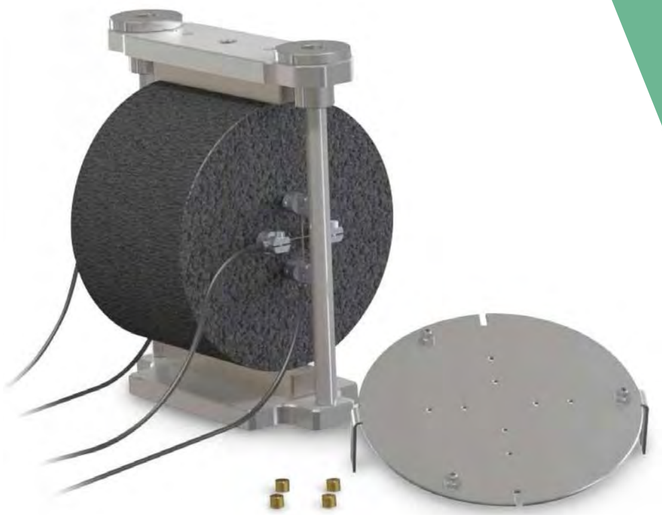
Balanced Mix Design

Green Asphalt IDT Tensile Strength Results:

SAMPLE	HT-IDT STRENGTH
A	34.24
B	39.91
C	43.15

State Requirements:

STATE	MINIMUM
AL	20
NYS	30



Balanced Mix Design

Green Asphalt Ideal CT Results:

SPECIMEN	CT INDEX
A	95
B	95.44
C	101.32
D	109.43
E	93.13
F	102.37
G	110.65
H	101.73
I	103.03
J	104.39
K	100.1
L	147.22
M	98.84
N	83.67
O	91.72
P	116.4

103.4 Avg.

State Requirements:

STATE DOT	Minimum CT Index
AL >1M ESAL	55
AL >10M ESAL	83
AL > 30M ESAL	110
MO	45
NYS	135
OK	100
PA	70
TN	50
VA	70
WI	30

High-RAP Conversion Process

Patent Licensing

Green Asphalt's goal is for all asphalt to be Green Asphalt.

The goal is to achieve this through licensing our patented Air Filtration Unit technology to other producers to allow them to increase their RAP content of their mixes.

The Air Filtration Unit removes Blue Smoke from high-RAP mixes.

RAP Problems

Monetize RAP that otherwise takes up valuable real estate

Environmental Regulations

Get ahead of the curve on environmental regulations

Increase Bottom Line

Produce an equally performing product for less money

Conversion Process

Green Asphalt will help convert existing asphalt plants (batch and drum plants) to be able to utilize our patented technology. This conversion process has three main steps.

1 RAP Management

The fractionation, stockpiling, and QA/QC process for managing RAP must be evaluated and altered to be able to produce viable mixes.

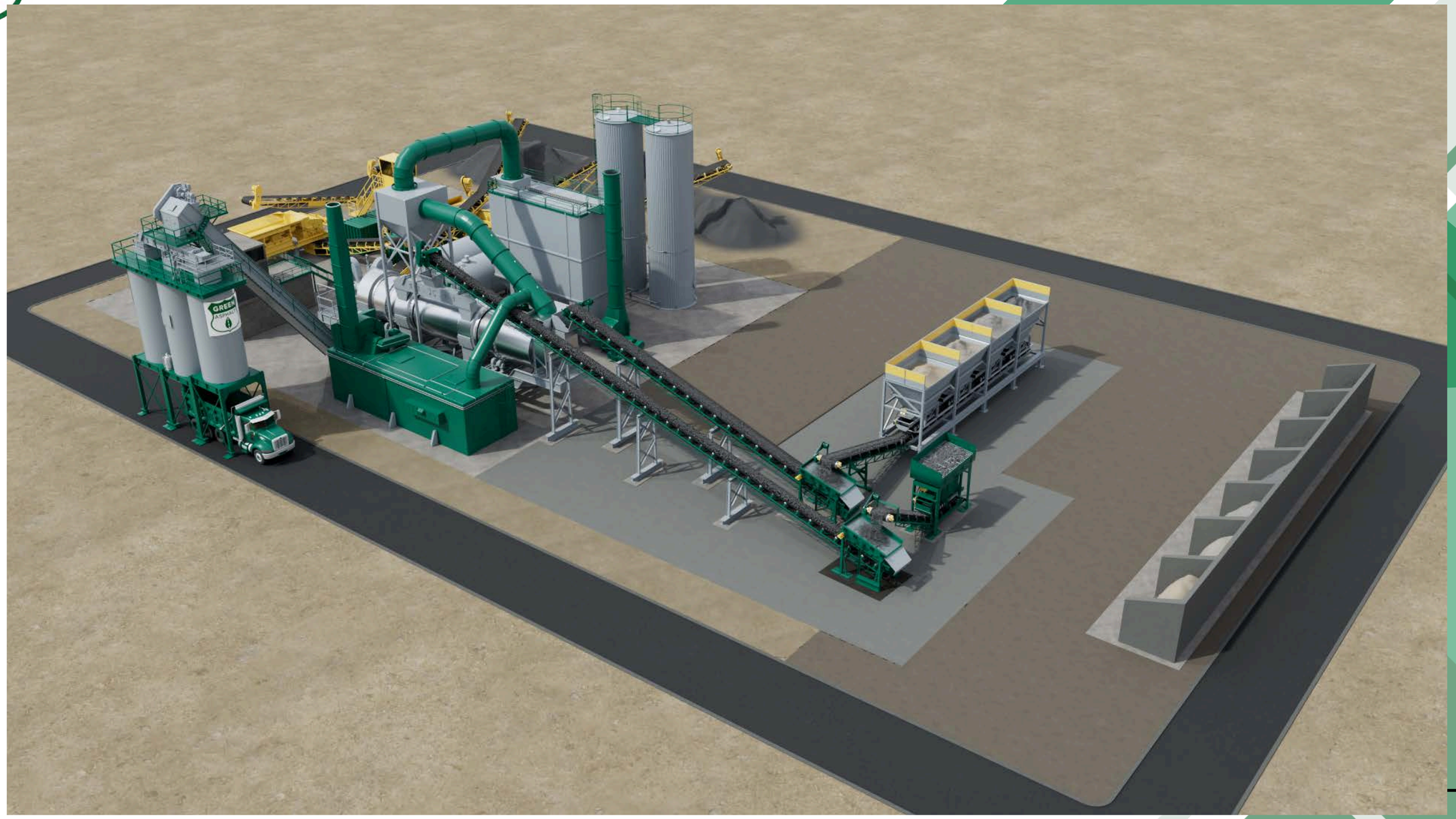
2 Mix Designs & Performance

Mixes will be designed based on the current customer base needs. Performance of high-RAP mixes should be tested to ensure equal characteristics.

Plant Conversion 3

Depending on the existing plant setup, equipment will be ordered and installed to allow for the use of the patented baghouse without interfering with the current asphalt production process.

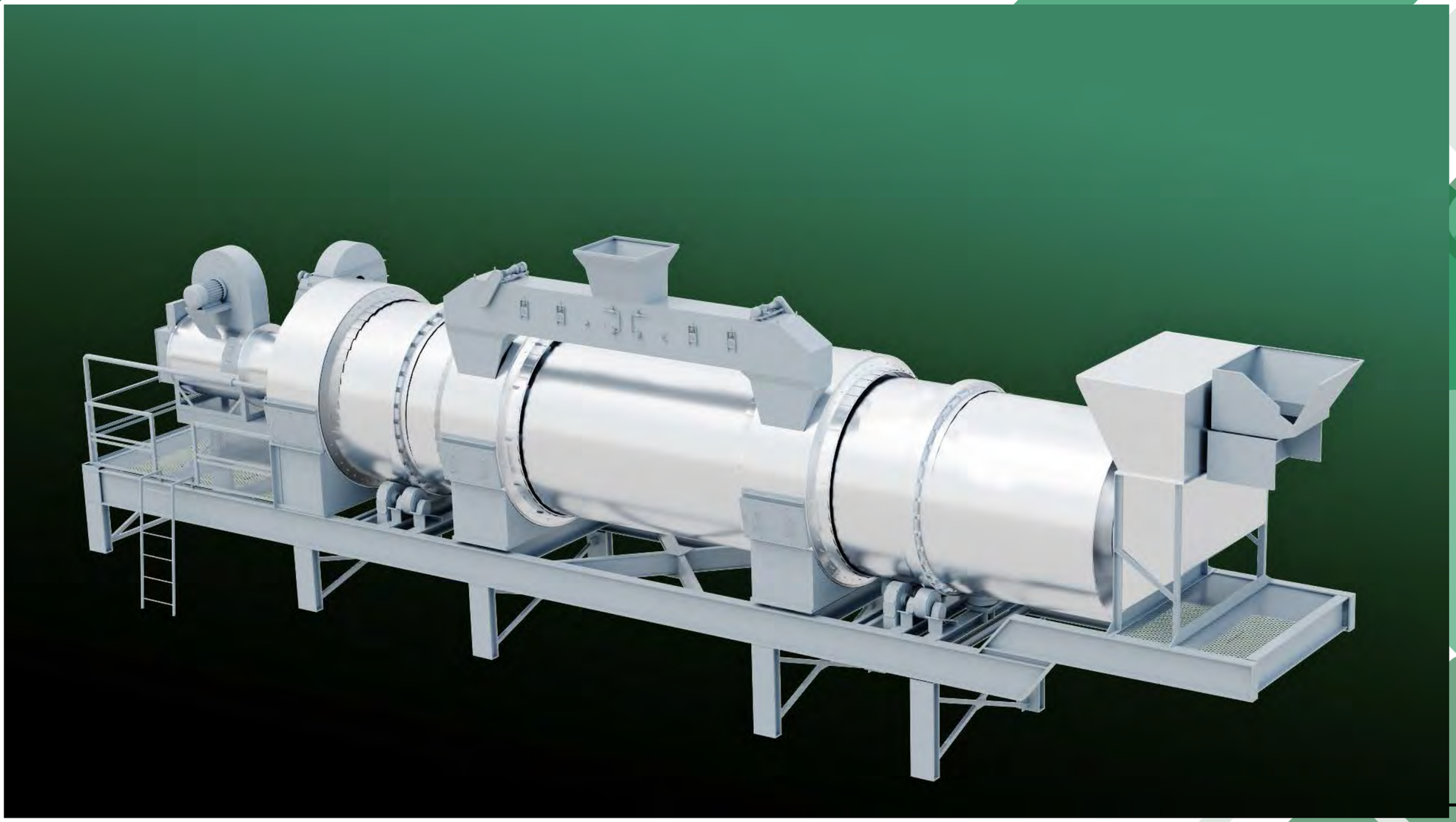
Plant Conversion



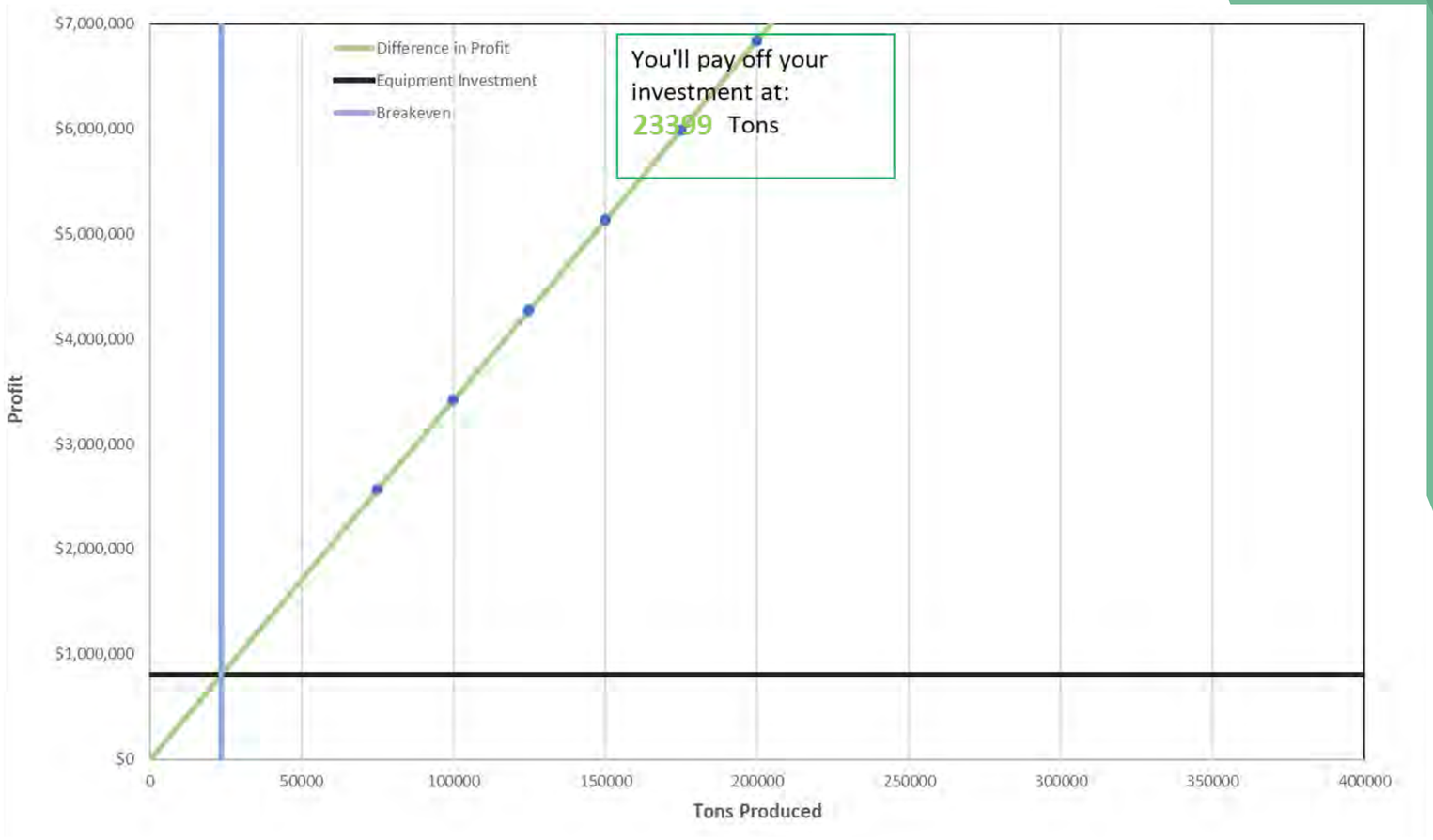
Plant Conversion

Plant Conversion

Plant Conversion



Plant Conversion



- Example for a plant currently producing 35% RAP
- Investment will be paid off after 23,400 tons
- The lower RAP content currently used, the faster the investment can be paid off

Get In Touch With Us

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Thank You

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