Quality Assurance Process for NCDOT Automated Data Collection

By

Ryan Finley

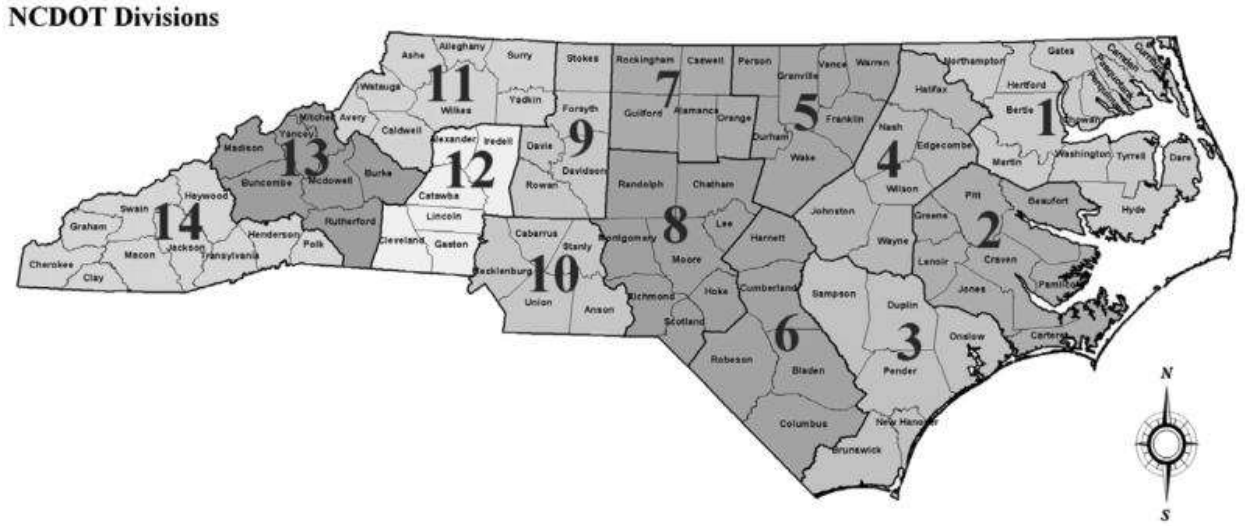
Quality Engineering Solutions, Inc.

RPUG Road Profile Users' Group

Background

- QES began quality monitoring in North Carolina in 2013
- Interstate, State, and US routes (occasional Secondary routes)
  - ~20,000 miles of primary routes annually
- 3D automated data collection vehicles
- Includes IRI, rutting, and faulting data
- Processed, rated, and QC’d by vendor
- Hard drives shipped to our Reno, NV office

Background (continued)



- 5% random sample selection by division
  - Rated in-house and compared to vendor provided distress ratings
- Deliverables submitted by division and pavement surface type
  - Asphalt surfaced divisions 1-14
  - Jointed concrete divisions submitted as one deliverable

Quality Assurance

- Rater training
  - Review of NCDOT High Speed Distress Manual, Version 1.0
- Rater calibration
  - A set of 5 quality assurance sites that are each 1-mile in length
  - Individual ratings compared to ‘ground truth’ ratings
  - Retraining if necessary to ensure 100% of samples fall within reasonable limits for each distress type
- Rater data continually reviewed as divisions are processed
- Further training provided if errors discovered post-processing

Quality Control using Distress Limits

- Development of distress limits by statistical means to identify random and/or systematic error in the vendor provided ratings
- Limits for distress types on asphalt concrete pavements (ACP)
  - Alligator cracking
  - Transverse cracking
  - Longitudinal cracking
  - Lane joint cracking
  - Patching
  - Bleeding

Quality Control using Distress Limits (continued)

- Limits for distress types on jointed concrete pavements (JCP)
  - Concrete patching
  - Asphalt patching
  - Longitudinal cracking
  - Corner breaks
  - Spalling
  - Transverse cracking
- Samples with distress types falling outside of limits are investigated to determine cause and uncover random and/or potential systematic errors in distress type and severity identification

Distress Limits Development

- Combined different distress severity levels to form a representative quantity for each distress type
  - Achieved by using a weighting system
  - Low severity having a weighting factor of 1, moderate severity having a weighting factor of 1.5, and high severity having a factor of 2
  - Weighted factors multiplied by total quantity of distress for each severity category to create a weighted quantity
  - All weighted quantities summed together to create a representative quantity

Distress Limits Development (continued)

- Example: A one-mile sample contains quantities of alligator cracking at varying severities. A rater identifies a total of 5,000 sqft of low severity, 2,000 sqft of moderate severity, and 500 sqft of high severity alligator cracking.

  The representative quantity would be
  (5,000)*1+(2,000)*1.5+(500)*2
  or 9,000 sqft of alligator cracking.

Distress Limits Development (continued)

- The representative quantity averaged over a maximum area of the sample to describe a percentage affected by the categorical distress.
- For alligator cracking, the maximum area was determined by multiplying 5,280 feet of sample length by the estimated wheel path widths of 7 feet (3.5 feet each).
- For longitudinal and lane joint cracking, a maximum of 5,280 feet of each was assumed.

Distress Limits Development (continued)

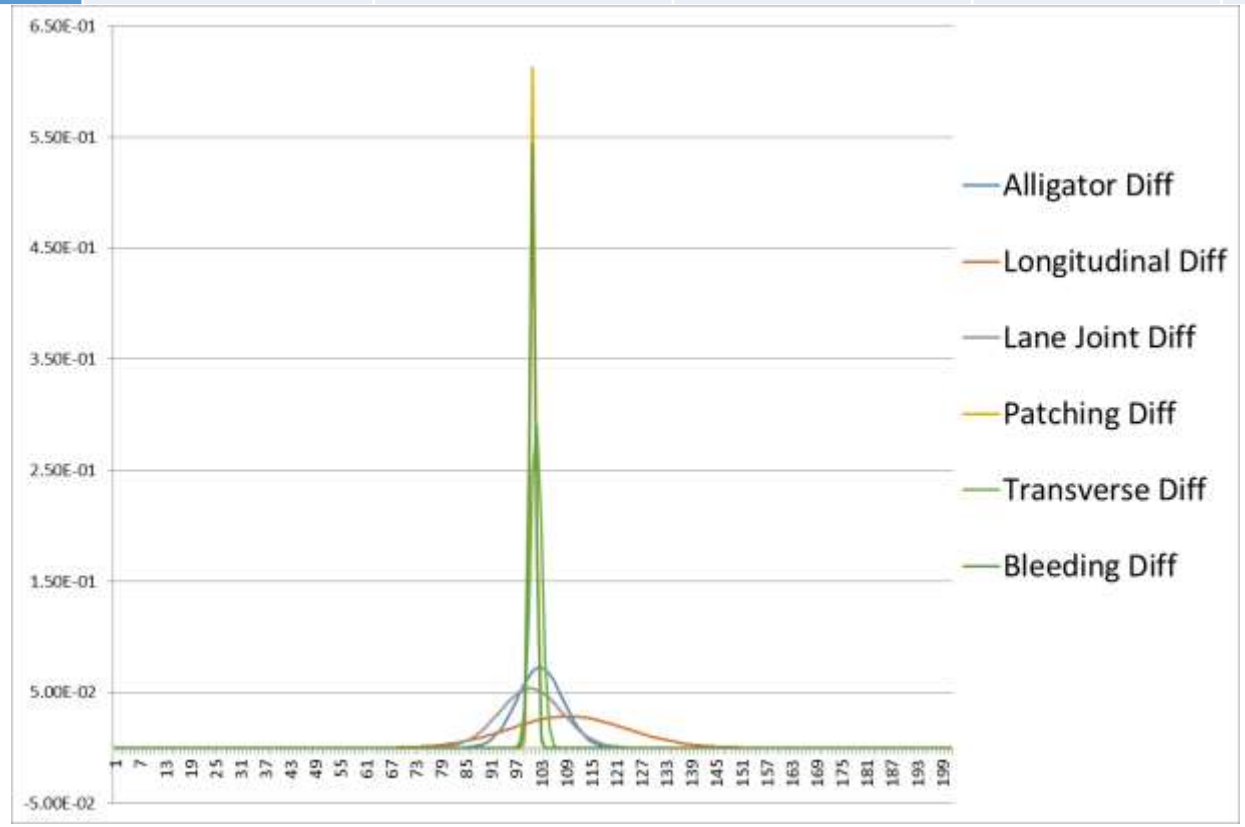
- For transverse cracking, a count had to first be estimated
  - Assumed full lane width crack length of 12 feet with maximum number of transverse cracks at 1 crack every foot
  - Results in defined ‘total’ number of cracks for a 5,280 foot sample
- JCP distress, counts were averaged over the total slab count to determine percentages
- Example: For a representative quantity of 9,000 sqft of alligator cracking on a one-mile sample, the percentage affected is 9,000*(5,280*7) or 24.4%.

Distress Limits Development (continued)

- For ACP sections, a total of 943 samples from 14 divisions were used to develop categorical distress limits.
- For JCP sections, a total of 106 samples from 8 divisions were used to develop categorical distress limits.
- In-house ratings were carefully checked for accuracy of the distress types, severities, and quantities in each of the samples.
- Representative quantity and percentages were calculated for each sample for both in-house and vendor provided ratings.
- 2 x SD

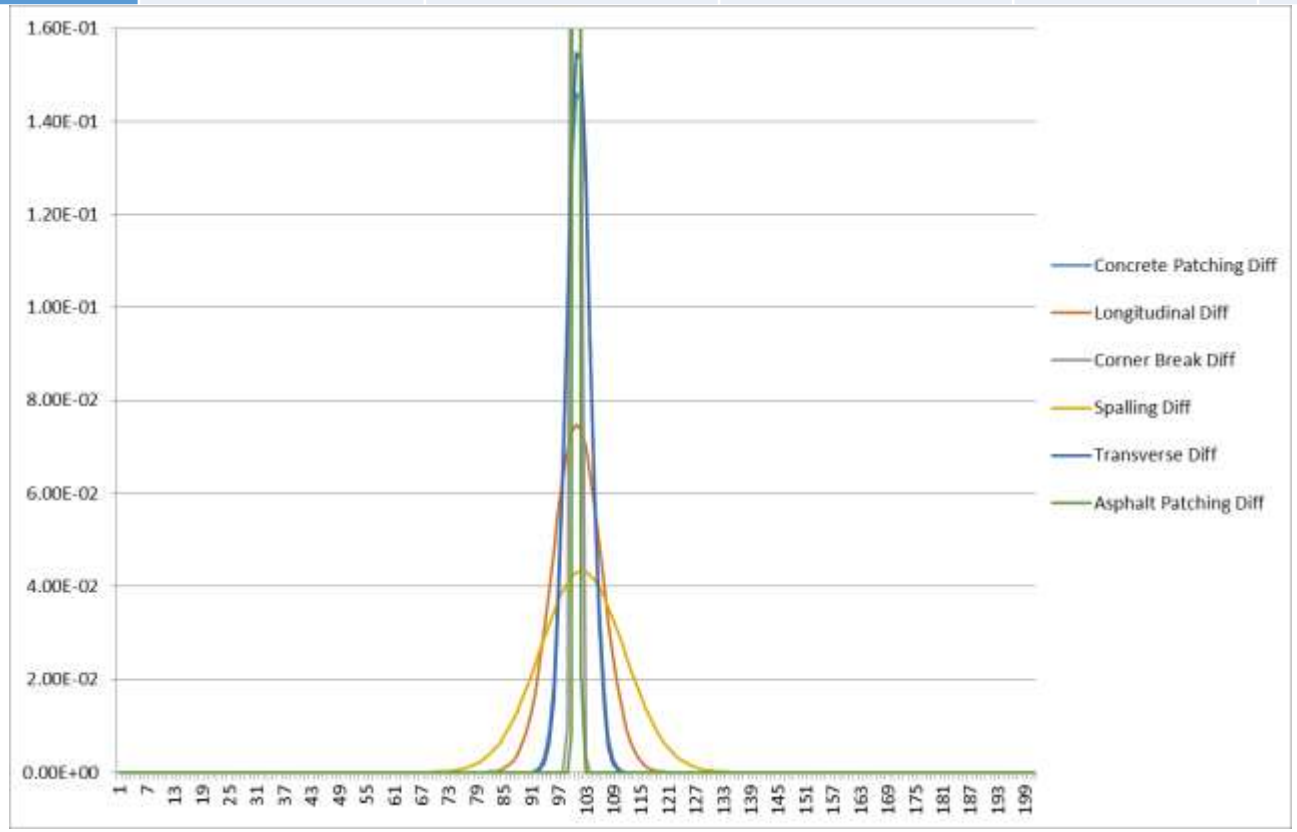
ACP Distress Limits

Limits Selected for Automated Distress	ACP Distress Type					
	Alligator Cracking	Transverse Cracking	Longitudinal Cracking	Lane Joint Cracking	Patching	Bleeding
2 x Standard Deviation	11.00	2.72	28.05	14.90	1.30	1.46



JCP Distress Limits

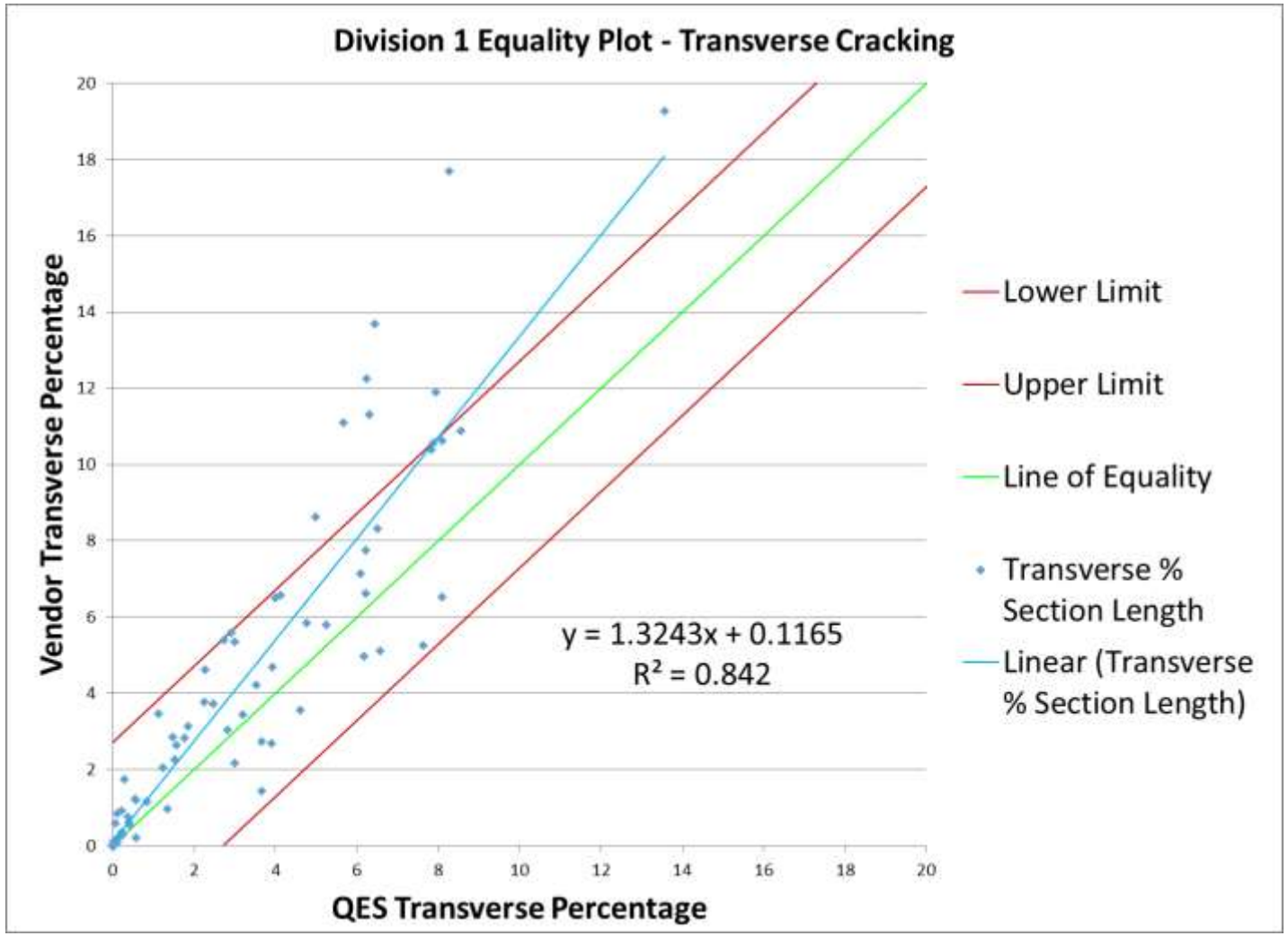
Limits Selected for Automated Distress	JCP Distress Type					
	Concrete Patching	Asphalt Patching	Longitudinal Cracking	Corner Break	Spalling	Transverse Cracking
2 x Standard Deviation	5.40	0.67	10.66	1.31	18.41	5.08



Quality Control using Bias Checks

- A line of equality plot with a trend line is plotted by distress type.
- Any distress types with a trend line slope value that falls outside of the range 0.8 and 1.2 indicates a categorical systematic difference in ratings with either a positive or negative bias.
- A small sample subset of the images are identified with ranges of distress values where the differences are more prevalent.
- A few additional samples with these identified ranges of distress values as rated by the vendor are selected to be rated in-house.
- The vendor and in-house ratings are then compared for each distress type and potential systematic differences are identified.

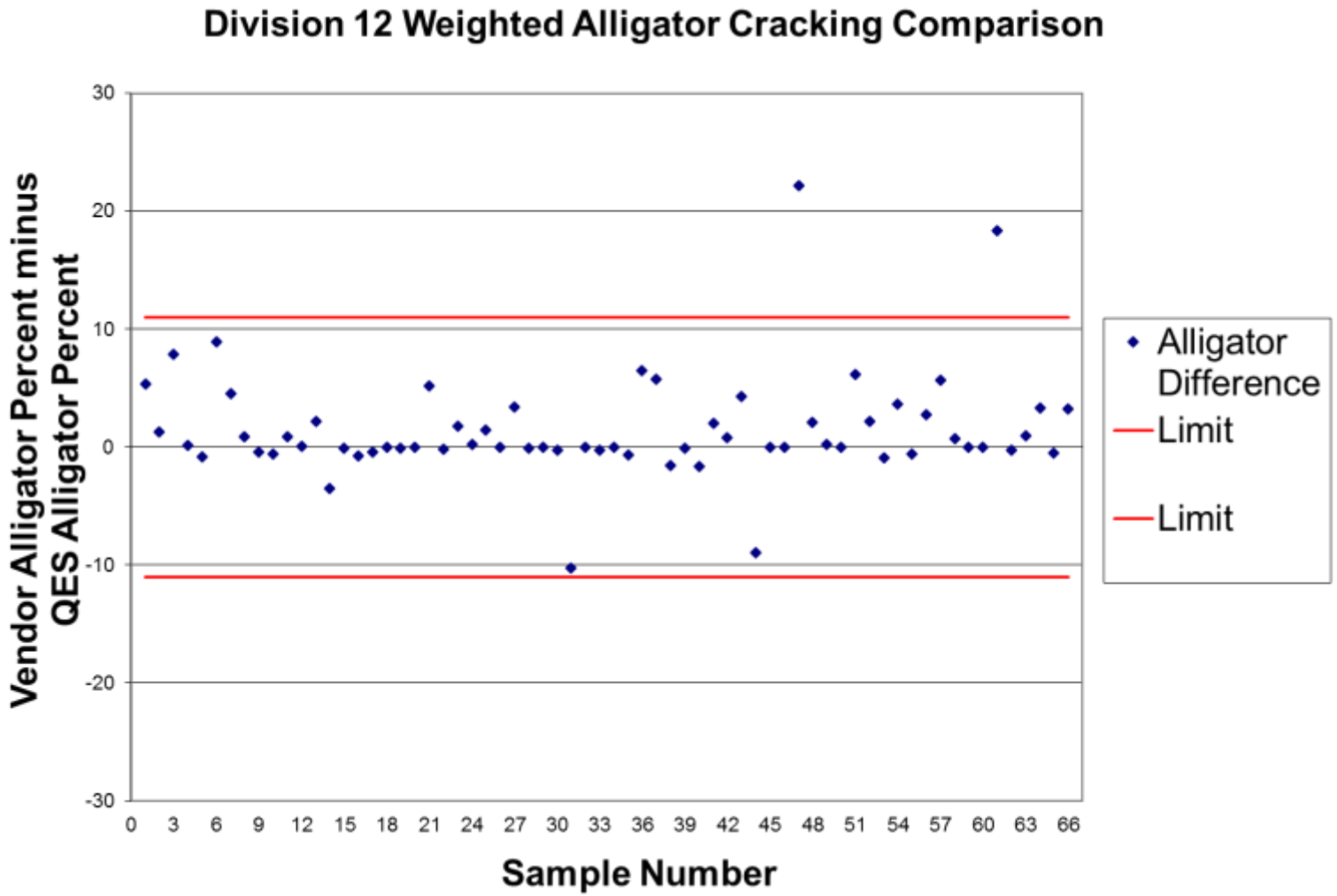
Equality Plot



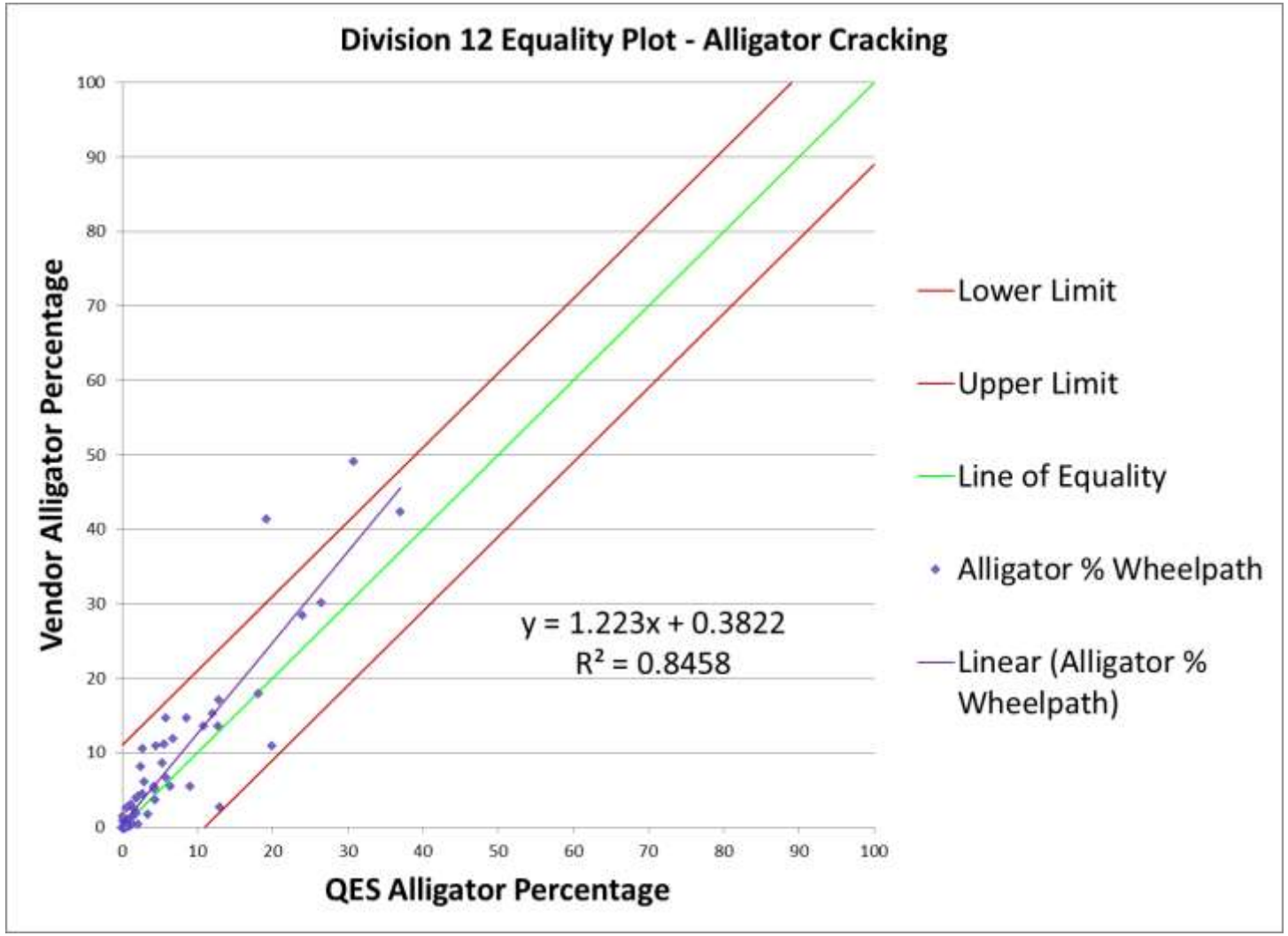
Case Study

- Case study from 2017 for division 12 ACP sections
- A hard drive deliverable was received from the vendor and consisted of a total of 1,303 miles of pavement
- A total of 66 one-mile samples were randomly selected
- Following in-house rating, processing, and sample comparison, a total of 2 samples were flagged for falling outside of their respective limit for alligator cracking
- Keep in mind that 97% of the deliverable fell within the designated distress limits for alligator cracking which suggests a random error

Case Study (continued)



Case Study (continued)



Case Study (continued)

- After reviewing the Equality Plot, a slight positive bias is evident with a trend line slope of 1.223
- Since the slope fell outside of the limits of 0.8 to 1.2, additional samples were selected to further investigate the bias
- A total of 2 additional samples were randomly selected where large quantities of alligator cracking had been identified by the vendor
- The additional samples were rated in-house, processed, and then compared to the vendor ratings

Case Study Conclusion

- Both additional samples (100%) were flagged for falling outside of their respective limits for alligator cracking.
- It was determined that the gutter joint along the right side of the roadway fell into the wheel path and was being misidentified by the software as alligator cracking for some road sections.
- This resulted in a significant increase in the quantity and severity of alligator cracking on some sections in division 12.
- The implementation of the bias check to supplement the distress limit QC check resulted in the discovery of a systematic error that may have otherwise been missed.

Summary

- Continual rater training and calibration are important.
- The selection of appropriate distress control limits are critical and should possibly be updated every few years to account for improvements in vendor's rating software.
- Update to reflect any changes in the vendor process.
- Combine these QA/QC methods with checks for bias to further enhance the discovery process of random and/or potential systematic errors in your data set.

Any Questions?