

## Plow Blade Optimization

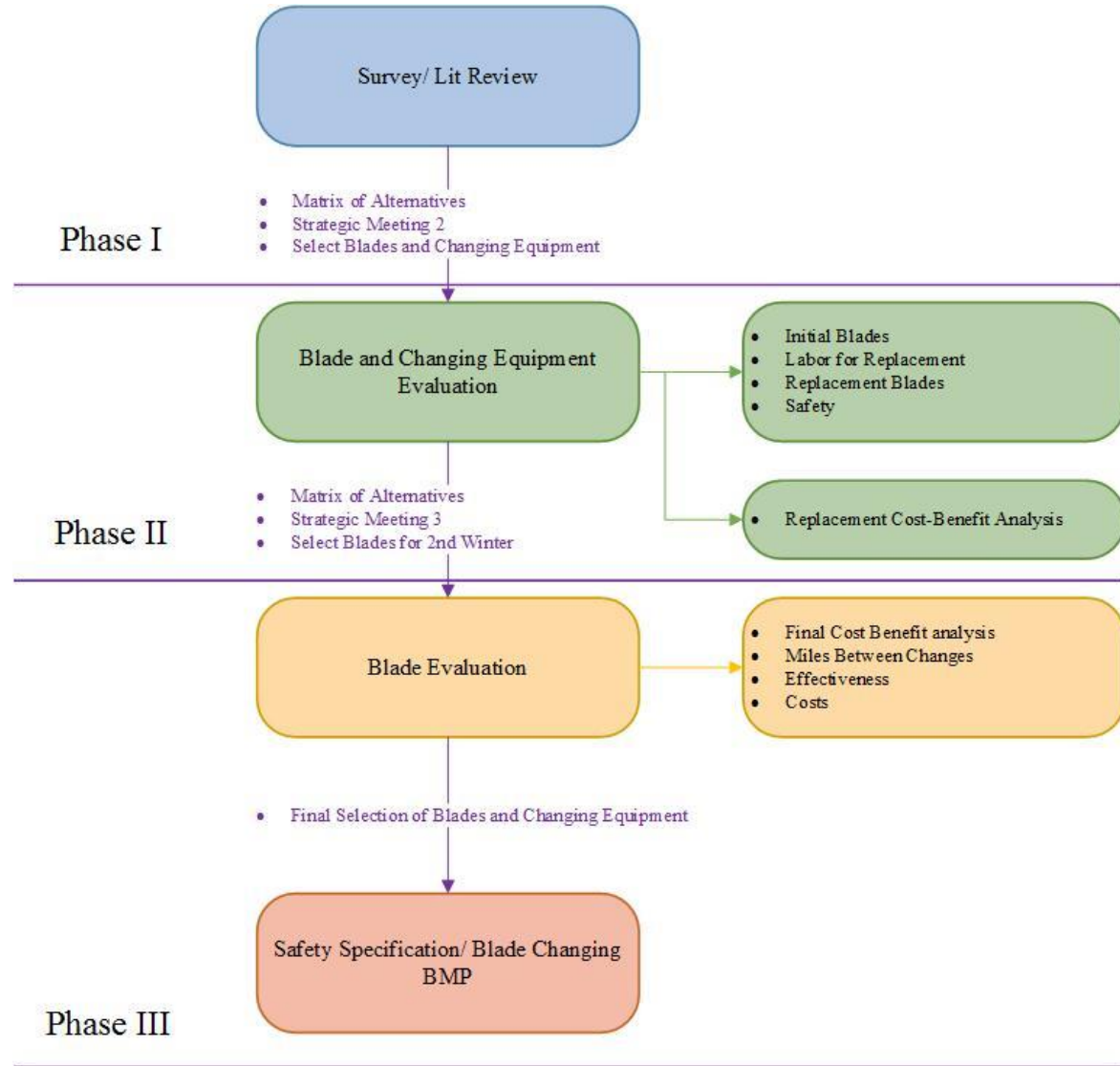
*This project was conducted in cooperation with ODOT and FHWA. The researchers would like to thank the members of ODOT's Technical Liaison Committee: Mr. Doug Riffle and Mr. Brian Olson. As well as ODOT's Statewide Planning and Research team: Ms. Vicky Fout, Ms. Jill Martindale, Ms. Cynthia Jones, Mr. Scott Phinney, and Ms. Kelly Nye.*



# The Ohio Department of Transportation

## Objective:

- Determine a usage strategy based on safe, efficient, and cost effective methods for changing and purchasing plow blades.



# The Ohio Department of Transportation

## Surveys

35 questions, phone interview of 81 ODOT county garages.

Literature Review and phone interviews with other states DOTs.

Goal: To determine the current ODOT and other DOT practices in regards to plow blades.

## Blades

### **Plow blade selection criteria:**

- Currently implemented by ODOT,
- Good reviews in other studies, or
- Made for DOT applications.

Goal: To test multiple blades to determine the most cost effective blade to use under certain conditions.

## Garages

### **Garage selection based on:**

- Annual average snowfall,
- Currently testing new blades,
- Plow at various speeds, or
- Plow various road surfaces.

Goal: To select multiple garages in order to test blades in varying speed, weather, and road types.

# Survey



## Surveys

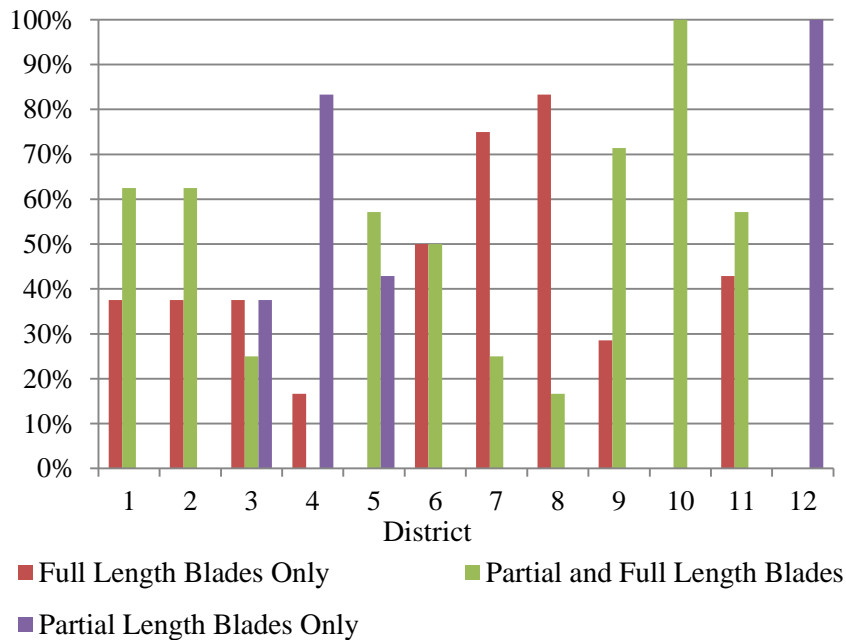
- In-State – 81 of 88 Ohio counties responded
- Determine current practices:
  - Blade section lengths,
  - Cover or stacked blades,
  - Blade materials,
  - Plow shoes,
  - Plow guards,
  - Trip edges,
  - Counter balances, and
  - Pavement type.

District \_\_\_\_\_ County \_\_\_\_\_  
Name \_\_\_\_\_ Date \_\_\_\_\_

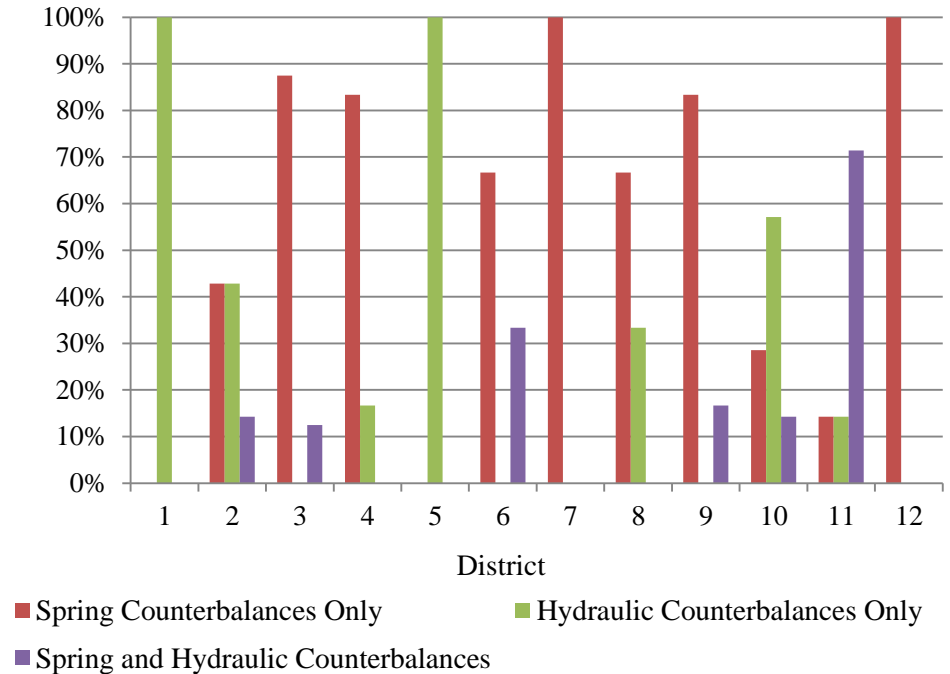
- 1.) What plowing systems are used in your county? (please check all that apply)  
 Front  Wing  Underbody  Tow plow
- 2.) How many lane-miles do you maintain? \_\_\_\_\_
- 3.) Do you pre-wet your salt?  
 Yes  No
- 4.) How many hours before a storm do you anti-ice?  
\_\_\_\_\_
- 5.) Do you use any kind of tripping mechanism?  
 Yes  No
- 6.) Do you use carbide inserts?  
 Yes  No
- 7.) Do you use plow shoes?  
 Yes  No
- 8.) Do you use plow guards?  
 Yes  No
- 9.) Do your plow systems have counter-balances on them?  
 Yes  No
- 10.) If yes, how often are they adjusted? \_\_\_\_\_
- 11.) What kind of counter-balance are used?  
 Spring  Hydraulic
- 12.) Do you use full length plow blades?  
 Yes  No
- 13.) Do you use partial length plow blades?  
 Yes  No
- 14.) Do you use a cover plow blade to cover the joint?  
 Yes  No
- 15.) What types of materials are the plow blades in your county? (please check all that apply)  
 Polymer  Rubber  Steel  Other \_\_\_\_\_
- 16.) What kind of road surface types are in your county? (please check all that apply)  
 Concrete  Asphalt  Chipseal
- 17.) Do you use different plow blades for different types of road surfaces?  
 Yes  No
- 18.) Do you use different plow blades in different weather conditions?  
 Yes  No
- 19.) Do you notice a difference in life span with different types of plow blades?  
 Yes  No
- 20.) If yes, please explain. \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_
- 21.) What are the lengths (in feet) of plow blades used in your county? \_\_\_\_\_
- 22.) What manufactures of plow blades do you use? (please list all) \_\_\_\_\_
- 23.) How many times a season do you change plow blades?  
\_\_\_\_\_
- 24.) How many people are needed to change plow blades?  
\_\_\_\_\_
- 25.) On average, how long does it take to change blades on one plowing system? \_\_\_\_\_
- 26.) Where does plow blade changing occur within your county? (please check all that apply)  
 County Garage  Outposts
- 27.) Which direction is the head of the bolts on the plow blades?  
 Facing the Front  Facing the back
- 28.) Do you have any safety protocol for changing plow blades?  
 Yes  No
- 29.) If yes, please explain. \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_
- 30.) Do you have a training program for changing plow blades?  
 Yes  No
- 31.) If yes, please explain. \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_
- 32.) On average, how many injuries do you experience from changing plow blades in a season? \_\_\_\_\_
- 33.) What tools and equipment do you use to change plow blades? \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_
- 34.) What are your biggest safety concerns when changing plow blades? \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_
- 35.) Are there any plow blades that you would like to have considered for evaluation? \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

## Survey Results – Blade Lengths and Counterbalances

Blade Section Length in Each District

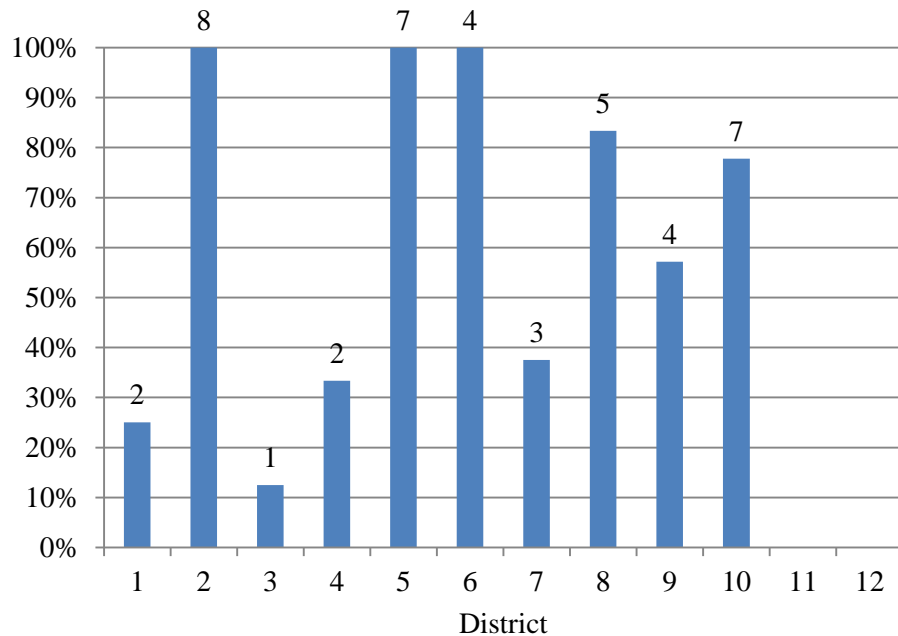


Types of Counterbalances Being Used in each District

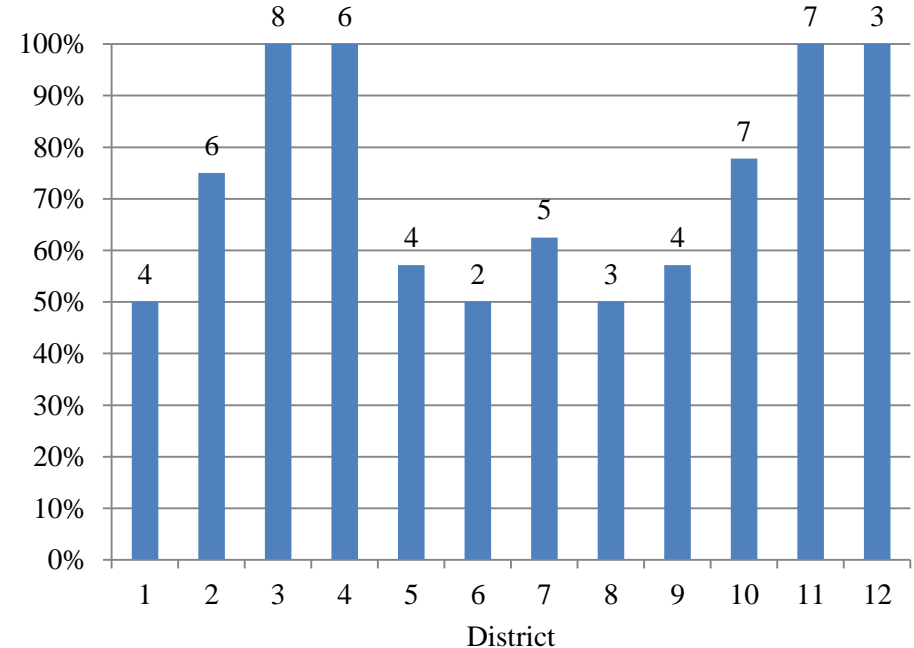


## Survey Results – Additional Blade Equipment

Plow Shoes Used in each District

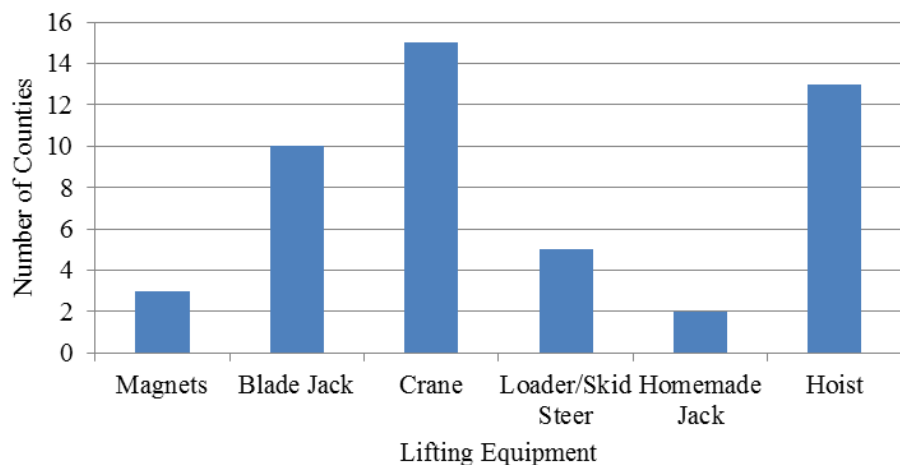


Plow Guards Used in each District

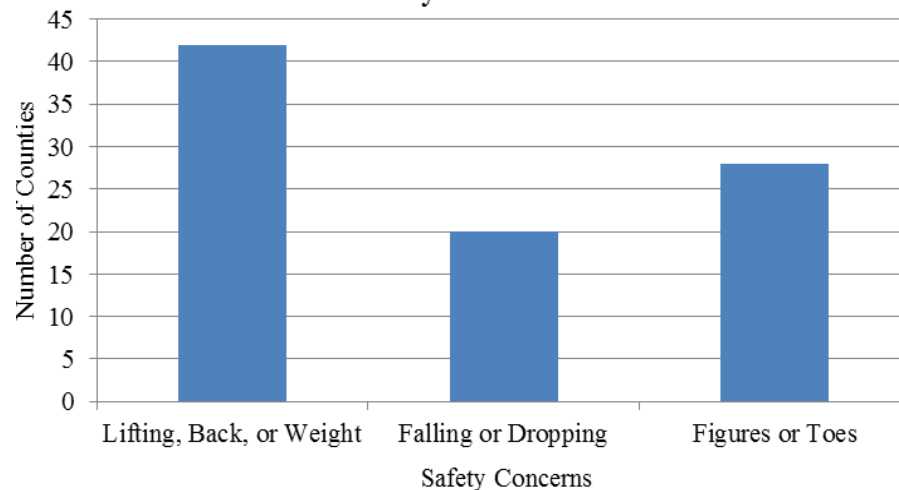


## Survey Results – Safety

### Equipment for Lifting Blades



### Safety Concerns





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# Project Setting and Data Collection Methodology

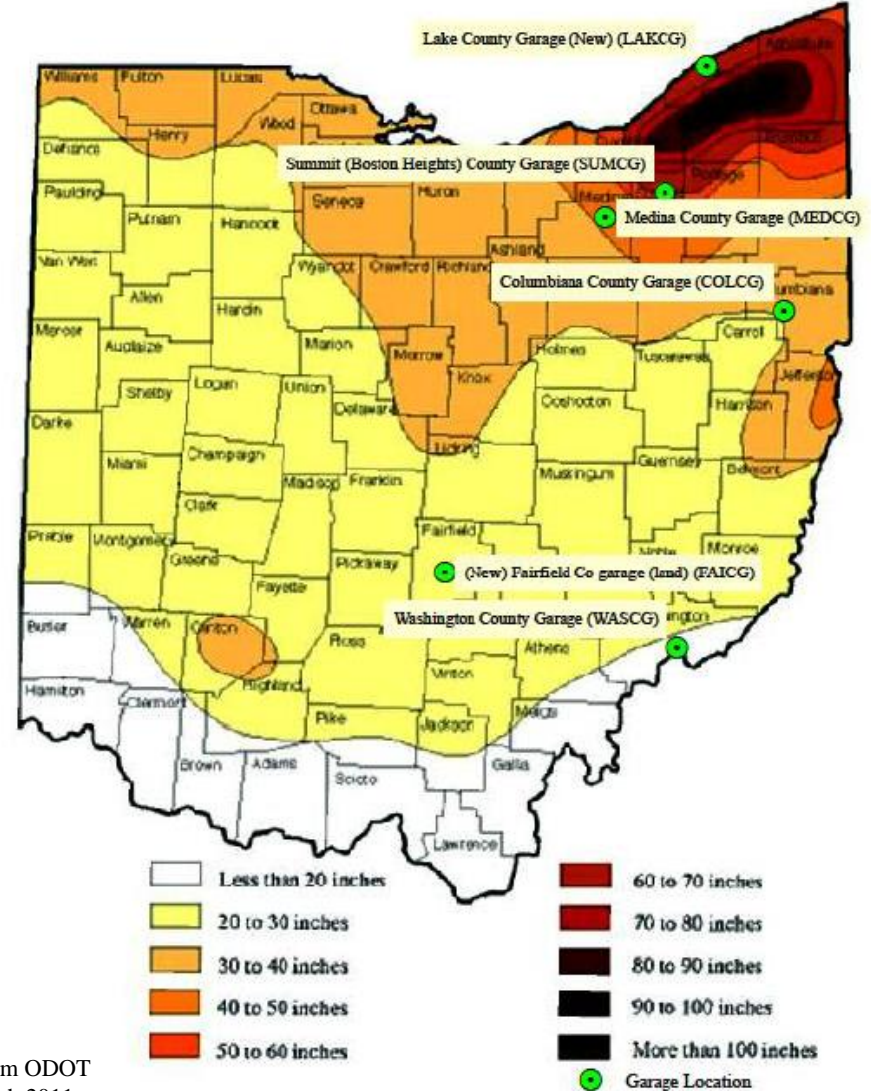


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## Project Setting

- D3 - Medina County
- D4 - Summit County
- D5 - Fairfield County
- D10 - Washington County
- D11 - Columbiana County
- D12 - Lake County



Background weather map from ODOT  
*Snow and Ice Practices*, March 2011

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County	Blades(*) (**)	Counterbalance	Snowfall (in.)
Medina	Steel, Carbide (Existing)**	Spring	30 – 60
Summit	Steel, JOMA (Spring)*, PolarFlex (Spring)*	Spring	40 – 80
Fairfield	Steel, Winter XL Classic (Hydraulic)*	Hydraulic	20 – 30
Washington	Steel, JOMA (Spring)*	Spring, Hydraulic	<20 – 30
Columbiana	Steel, Winter XL Classic (Hydraulic*, Existing**)	Spring, Hydraulic	20 – 40
Lake	Steel, PolarFlex (Spring*, Existing**)	Spring	60 – 100

Note: (\*) Indicates the type of counterbalance that should be on the truck the specific blade type is placed on.

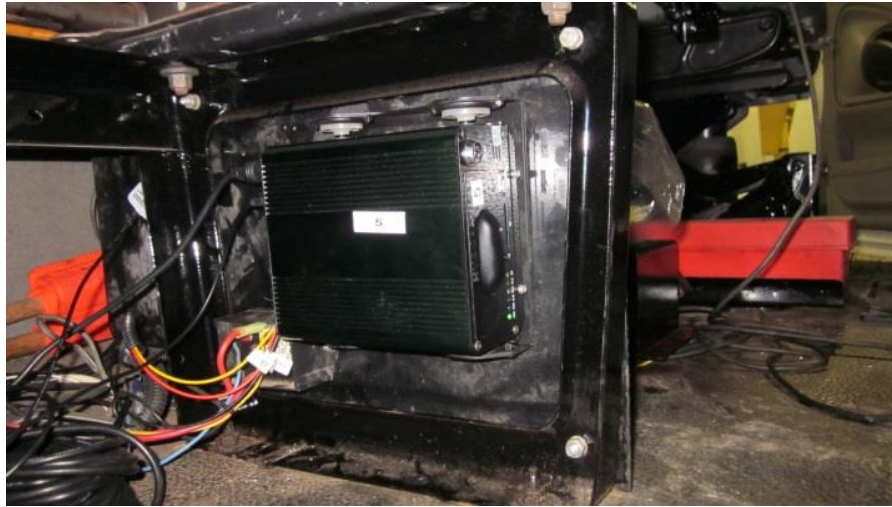
(\*\*) Indicates the blade type is currently being used in the county.



County	Counterbalance	Blade 1	Blade 2	Blade 3	Blade 4
Medina	Spring	Standard	XL Classic	PolarFlex	Middle Guard
Summit	Spring	Standard	XL Classic	Carbide	No Counterbalance
Lake	Spring	Standard	XL Classic	Carbide	Middle Guard
Fairfield	Hydraulic	Standard	PolarFlex	Carbide	Double Stacked
Washington	Hydraulic	Standard	PolarFlex	Double Stacked	No Counterbalance

Note: “Middle Guard” refers to a standard blade configuration with an additional straight edge guard placed in the middle of the blade. “No Counterbalance” refers to a standard blade configuration with no counterbalance used over the course of the season. “Double Stacked” refers to a setup having two full standard steel blades with straight edge guards on each end.

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DVR – Installed under seat



Front facing camera



Blade measurement locations

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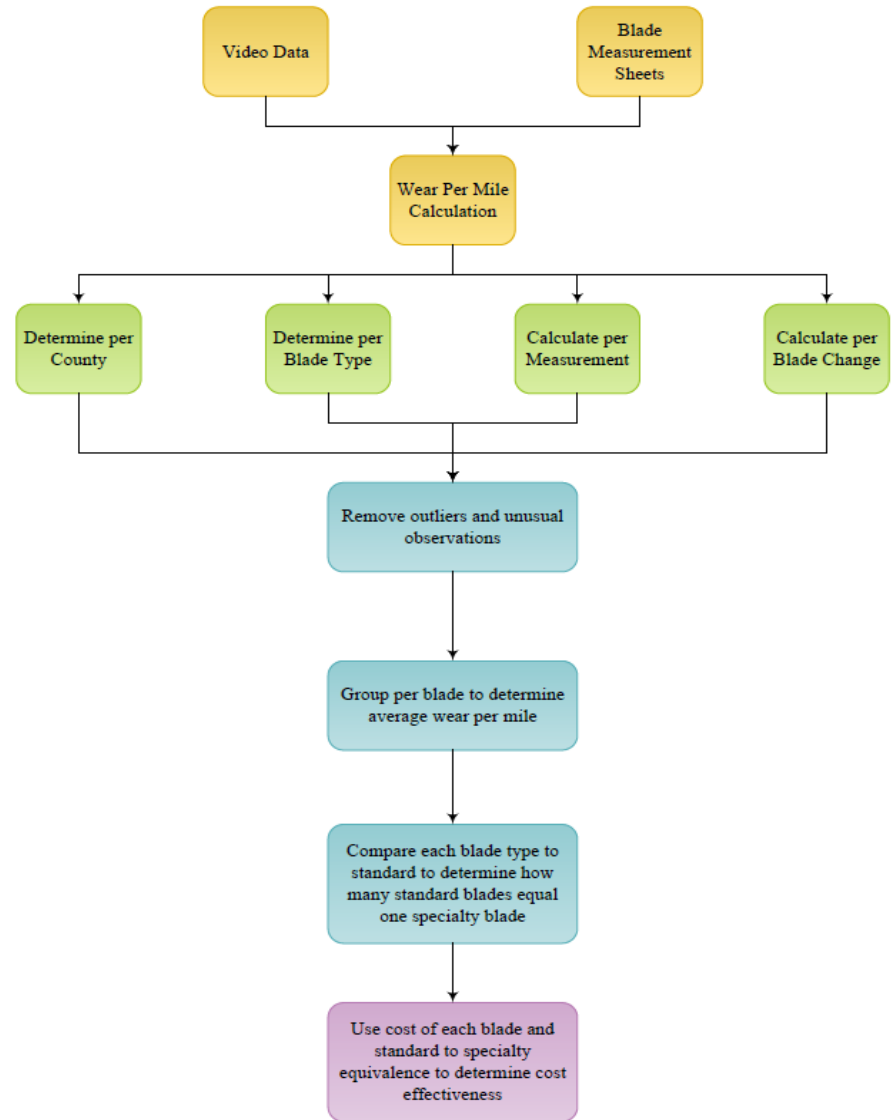
# Results



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- 6000+ hours of video data over two years
- Over 90% capture rate
- Measurement Sheets



# The Ohio Department of Transportation

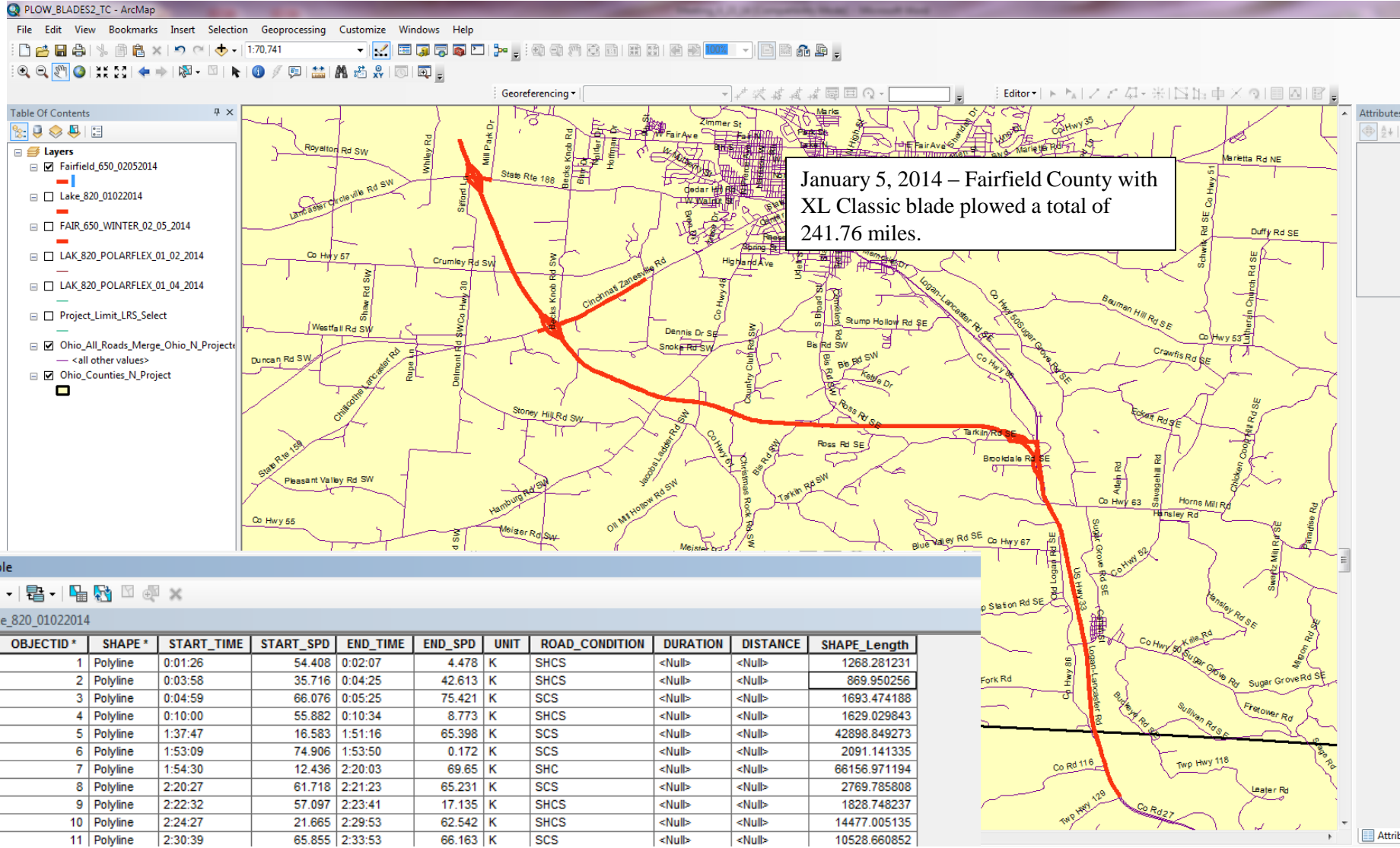


A) Plow in “Down” Position, Utilized



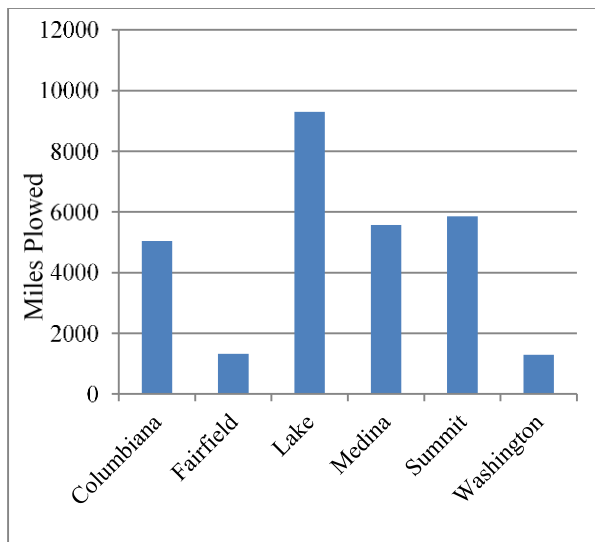
B) Plow in “Up” Position, not Utilized

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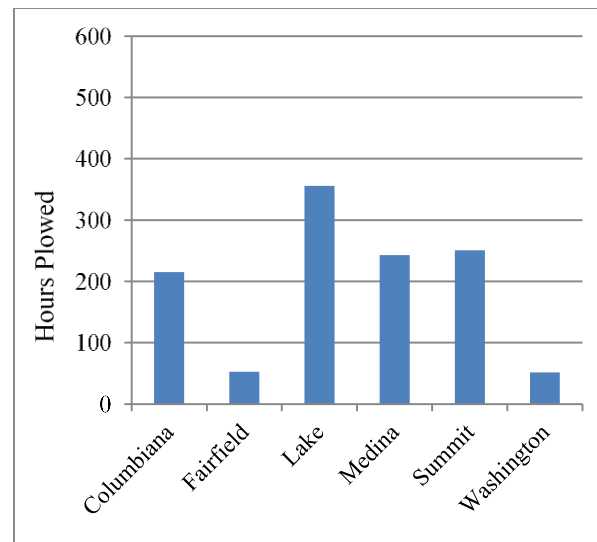




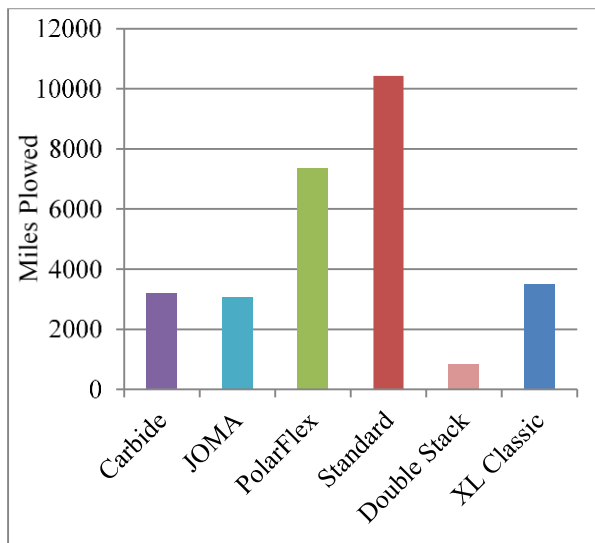
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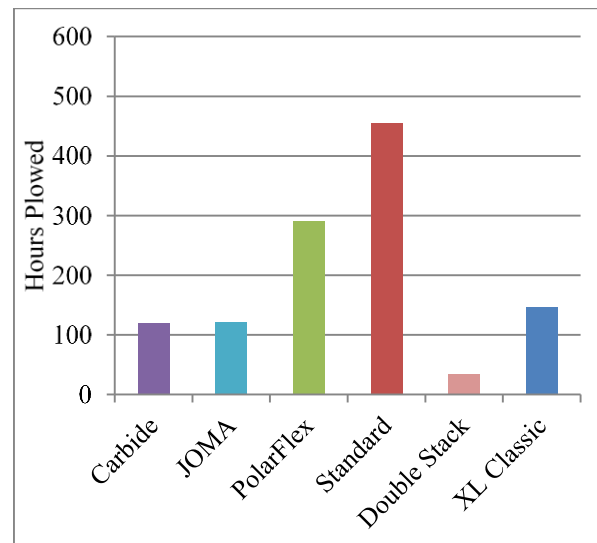
A) Distance Plowed Per County



B) Time Plowed Per County

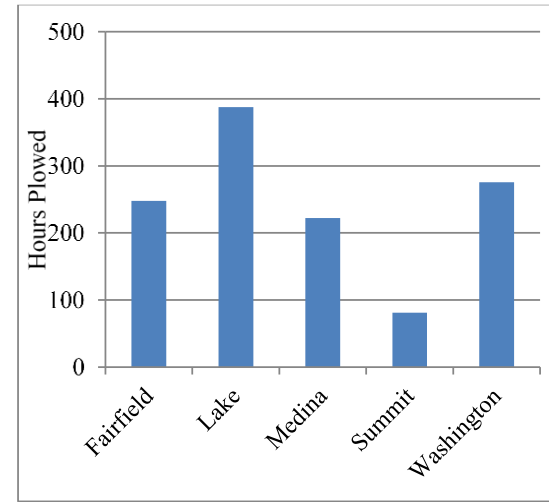
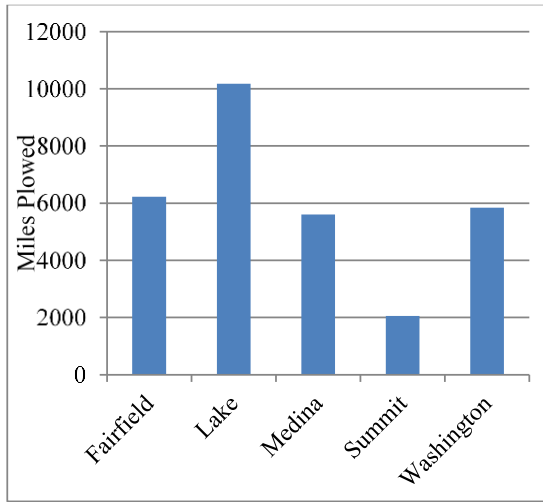


C) Distance Plowed by Blade Type



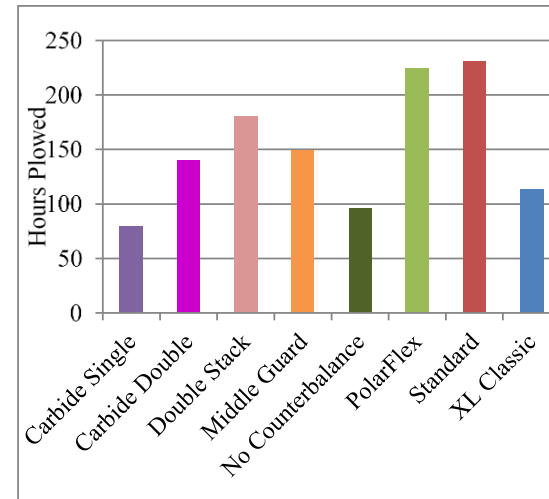
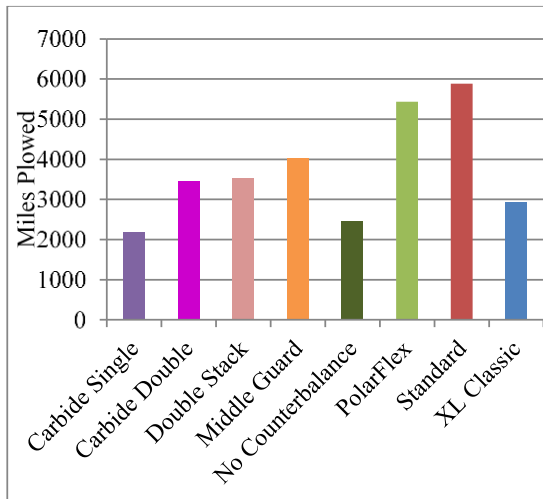
D) Time Plowed by Blade Type

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A) Distance Plowed Per County

B) Time Plowed Per County

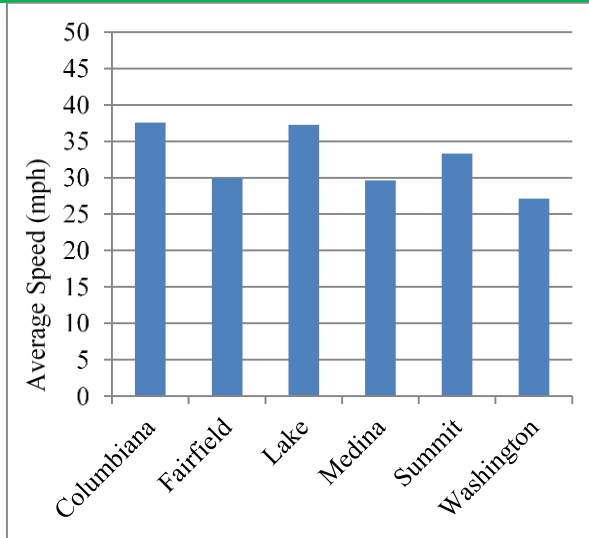


C) Distance Plowed by Blade Type

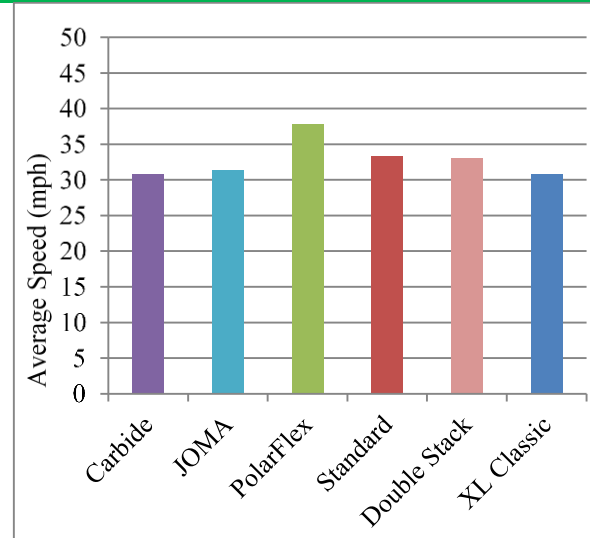
D) Time Plowed by Blade Type

Note: "No Counterbalance" is a standard blade on a truck without a counterbalance.

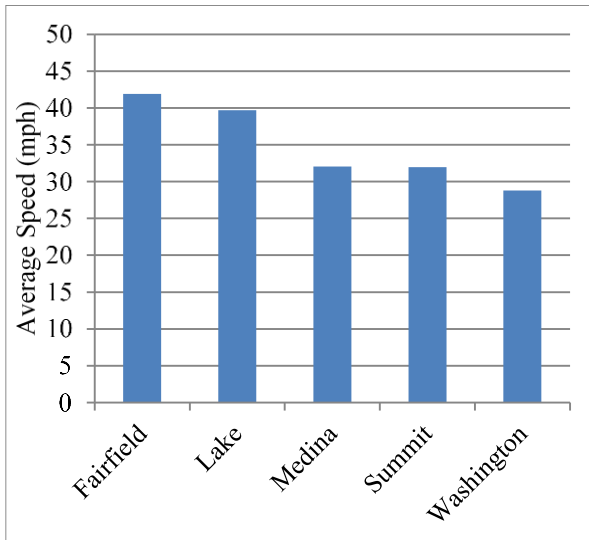
# The Ohio Department of Transportation



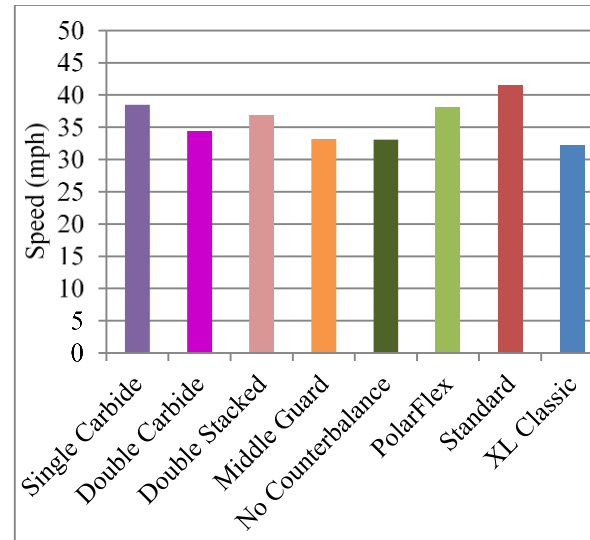
A) Average Plowing Speed Per County



B) Average Plowing Speed by Blade Type



C) Average Plowing Speed Per County



D) Average Plowing Speed by Blade Type

Note: "No Counterbalance" is a standard blade on a truck without a counterbalance.

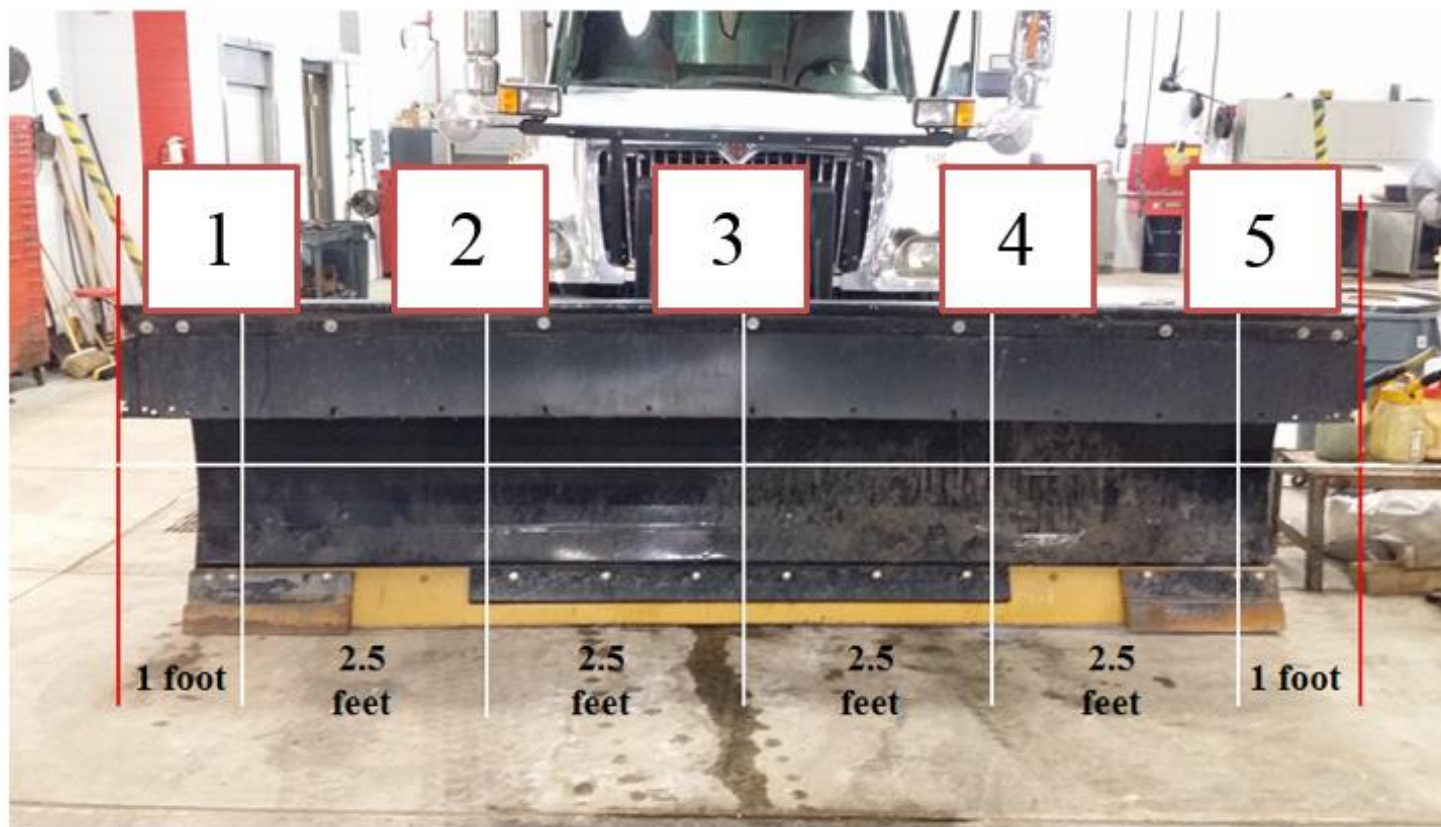
## Pavement Type and Bridge Joints – Year Two



<b>County</b>	<b>Blade</b>	<b>Number of Joints</b>	<b>Percent Concrete</b>
Fairfield	Carbide - Single	2386	3.6%
Fairfield	Carbide - Double	4518	3.99%
Fairfield	Double Stack	11076	2.13%
Fairfield	Standard	18	0.03%
Fairfield	PolarFlex	10032	2%
Lake	Carbide - Single	0	0%
Lake	Carbide - Double	664	0.14%
Lake	Middle Guard	1316	0.56%
Lake	Standard	8902	2.34%
Lake	XL Classic	12526	25.67%
Medina	Middle Guard	2860	0.83%
Medina	PolarFlex	808	0.44%
Medina	Standard	1038	0.72%
Medina	XL Classic	760	0.75%
Summit	Carbide - Double	526	1.34%
Summit	No Counterbalance	8334	7.65%
Summit	XL Classic	268	0.18%
Washington	Double Stack	1624	1.4%
Washington	No Counterbalance	0	0%
Washington	PolarFlex	0	0%
Washington	Standard	844	0.46%

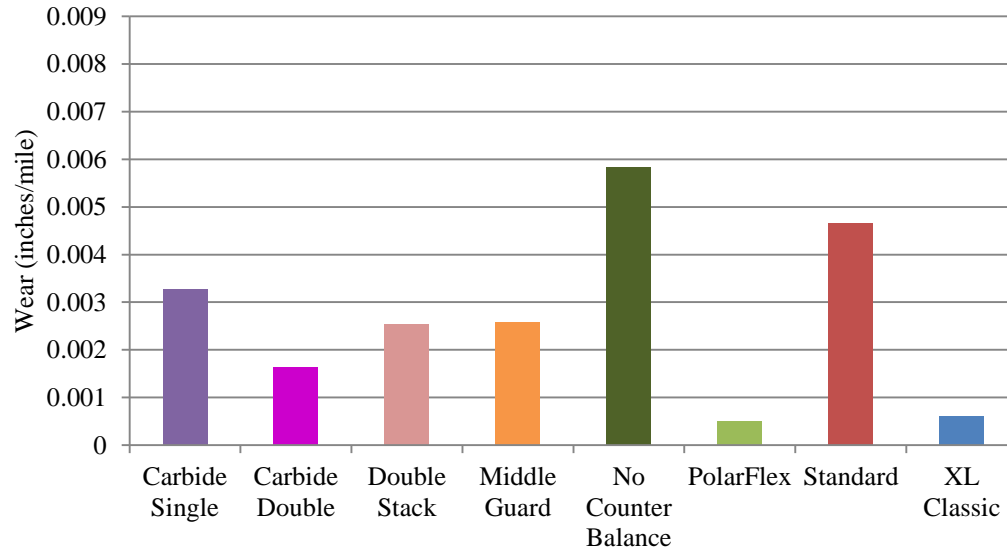
Note: The number of joints is calculated by counting the number of concrete segments plowed and multiplying by two. This method assumes that each concrete segment is a bridge deck with two joints at each end. “No Counterbalance” is a standard blade on a truck with no counterbalance.

# Blade Measurements Results

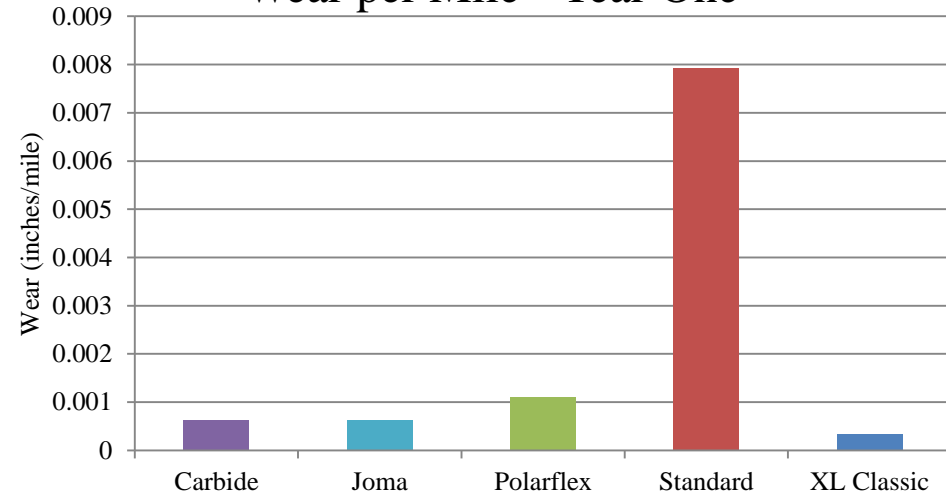


## Wear per Mile Plowing

### Wear per Mile - Year Two






### Wear per Mile - Year One

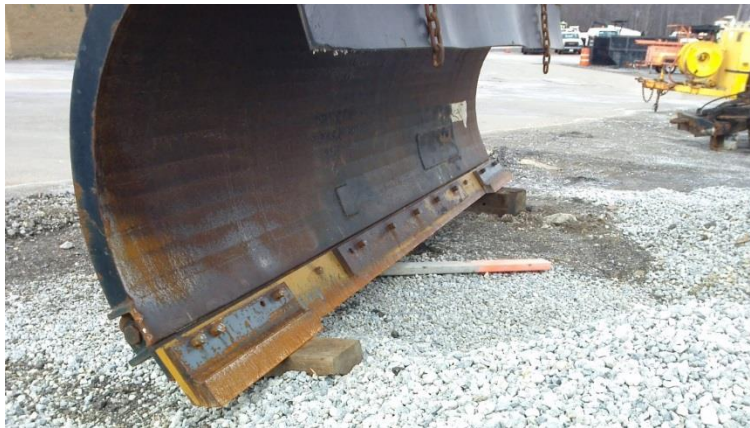


- Using video data and blade measurement sheets, the wear per mile may be calculated.

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County	Blade Type	2013-2014 Winter Season Notes	Picture
Summit	JOMA	Lost driver-side curb guard on barrier wall drain. Still used plow without curb guard. Picture is of JOMA with missing a curb guard.	
Summit	PolarFlex	1/26/2014 Hit bridge expansion joint – middle section was bent to point of being unusable. Ordered new teeth for blade. New teeth install on 2/5/2014.	
Summit	PolarFlex	Hit monument box. Slightly bent middle section and trip edge. Still used plow. Went through three trip edges this season.	
Medina	Carbide	1/26/2014 Broke first carbide blade on bridge expansion.	N/A

## Blade Ratio



<b>Blade Type</b>	<b>Average Total Wear (in)</b>	<b>Total Miles</b>	<b>Wear/Mile (in/mile)</b>	<b>Equivalent Standard Blade Ratio</b>
Carbide	1.975	1709.2	1.16 E-03	1.7
JOMA	1.225	3060	4.00 E-04	5.0
PolarFlex	2.4375	5547	4.39 E-04	4.5
Standard	15.2	7666.6	1.98 E-03	1
XL Classic	0.95	3185.8	2.98 E-04	6.6

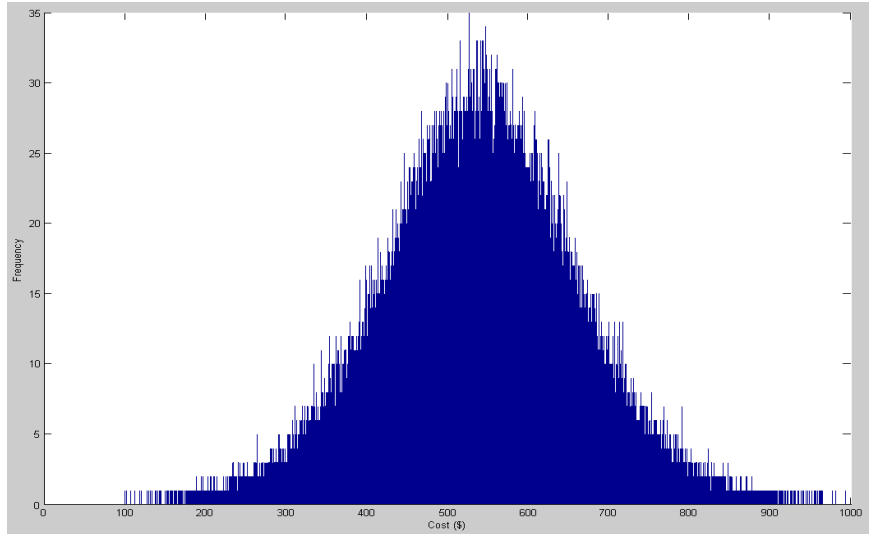
Note: Fairfield's double-stacked standard blade is an outlier to the data and is removed from the analysis; therefore, it is not presented in this table. In Year Two of this study, additional double-stacked blades are tested in order to determine a standard blade equivalence ratio, presented in Table 6.4.

<b>Blade Type</b>	<b>Average Total Wear (in)</b>	<b>Total Miles</b>	<b>Wear/Mile (in/mile)</b>	<b>Equivalent Standard Blade Ratio</b>
Carbide - Single	3.00	917	3.27E-03	1.5
Carbide - Double	6.13	3733	1.64E-03	2.9
Double Stack	8.31	3278	2.54E-03	1.9
Middle Guard	8.00	3115	2.57E-03	1.9
No Counterbalance	5.75	986	5.83E-03	0.8
PolarFlex	1.94	3929	4.93E-04	9.4
Standard	16.94	3510	4.82E-03	1
XL Classic	1.63	2698	6.02E-04	7.7

Note: The average wear is determined from adding the wear of each measurement location over the entire season for each blade type, in each county, then averaging the wear across the blade. "No Counterbalance" is a standard blade on a truck with no counterbalance.



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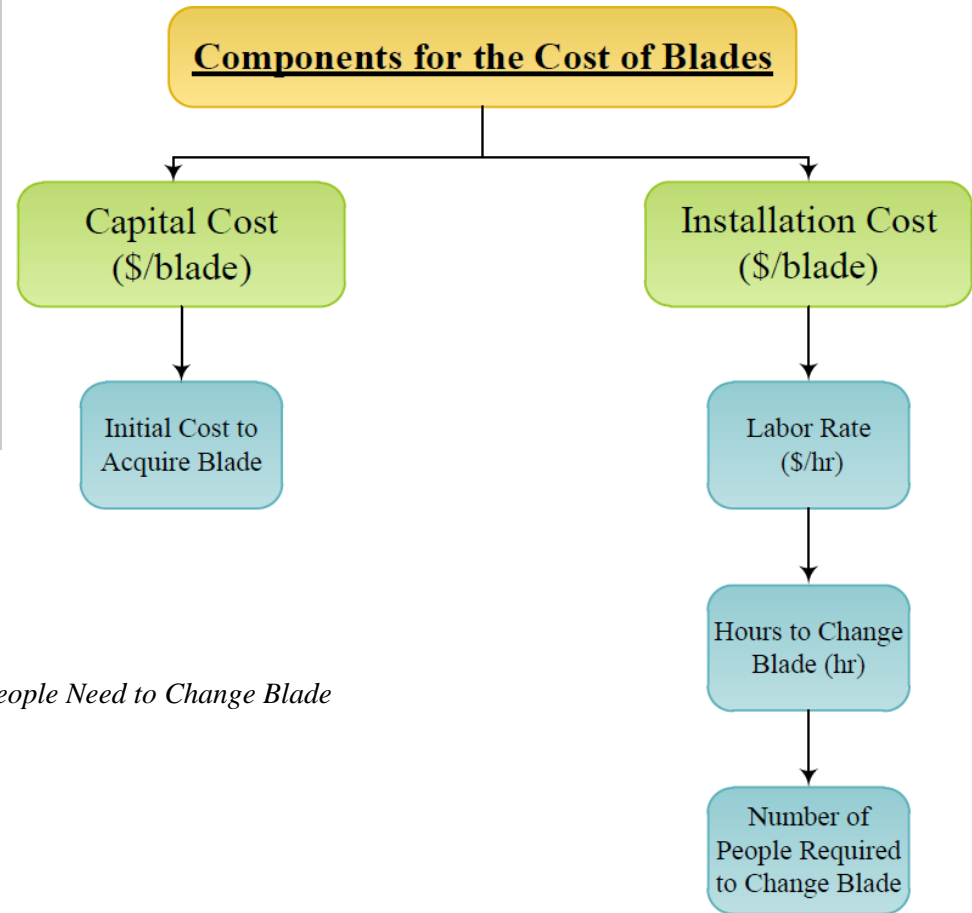
$$\text{Cost (\$)} = \text{Capital Cost (\$)} + \text{Installation Cost (\$)}$$

*Installation Cost (\\$) =*

$$\text{Labor Rate (\$/hr)} \times \text{Hours to Change Blade (hr)} \times \text{Number of People Need to Change Blade}$$

$$\text{Each blade's wear rate (in/mil)} = \frac{\text{Total Wear Observed (in)}}{\text{Total Plowing Miles (mile)}}$$

$$\text{Equivalent Standard Blade Ratio} = \frac{\text{Wear per mile of the Standard Blade}}{\text{Wear per mile of the Specialty Blade}}$$



# The Ohio Department of Transportation

## Year One

	<b>Variables</b>	<b>Average</b>	<b>Standard Deviation</b>	<b>Source</b>
<b>Capital Cost</b>	Carbide-Tipped Blade Capital Cost (\$)	796.4	90.8	ODOT
	JOMA Blade Capital Cost (\$)	3361.8	--	Field Evaluation
	PolarFlex Blade Capital Cost (\$)	2466.0	--	Field Evaluation
	Standard Blade Capital Cost (\$)	498.3	97.8	ODOT
	Winter XL Classic Blade Capital Cost (\$)	2980.0	--	Field Evaluation
<b>Labor Cost</b>	Hourly Labor Rate (\$/hour)	18	3	ODOT
	Number of People to Change One Blade (unitless)	3	0.5	ODOT
	Time to Change One Blade (hour)	0.75	0.25	ODOT
<b>Standard Blade Cost Factor Multiplier</b>	Carbide-Tipped Blade Equivalence	1.7	0.5	Field Evaluation
	JOMA Blade Equivalence	5	0.5	Field Evaluation
	PolarFlex Blade Equivalence	4.5	0.5	Field Evaluation
	Winter XL Classic Blade Equivalence	6.6	0.5	Field Evaluation

Note: All data are provided by or approved by ODOT to reflect their current practices. Blade equivalencies are calculated from field data. The cost of standard and carbide blades are calculated using pricing from 201 to 2014.

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Year Two

	<b>Variables</b>	<b>Average</b>	<b>Standard Deviation</b>	<b>Source</b>
<b>Capital Cost</b>	Standard Blade Capital Cost (\$)	498.3	97.8	ODOT
	Double-Stacked Blade Capital Cost (\$)	704.2	149.7	ODOT
	Carbide-Tipped Blade Capital Cost (\$)	796.4	90.8	ODOT
	Double-Stacked Carbide-Tipped Blade Capital Cost (\$)	1375.2	156.5	ODOT
	Standard Blade with Middle Guard Capital Cost (\$)	607.0	110.5	ODOT
	PolarFlex Blade Capital Cost (\$)	2466.0	--	Field Evaluation
	Winter XL Classic Blade Capital Cost (\$)	2980.0	--	Field Evaluation
<b>Labor Cost</b>	Hourly Labor Rate (\$/hour)	18	3	ODOT
	Number of People to Change One Blade (unitless)	3	0.5	ODOT
	Time to Change One Blade (hour)	0.75	0.25	ODOT
<b>Standard Blade Cost Factor Multiplier</b>	Carbide-Tipped Blade Equivalence	1.5	0.5	Field Evaluation
	Carbide-Tipped Double Stacked Blade Equivalence	2.9	0.5	Field Evaluation
	Double Stacked Standard Blade Equivalence	1.9	0.5	Field Evaluation
	Middle Guard Standard Blade Equivalence	1.9	0.5	Field Evaluation
	No Counterbalance Standard Blade Equivalence	0.8	0.5	Field Evaluation
	PolarFlex Blade Equivalence	9.4	0.5	Field Evaluation
	Winter XL Classic Blade Equivalence	7.7	0.5	Field Evaluation

Note: All data are provided by or approved by ODOT to reflect their current practices. Blade equivalencies are calculated from field data. The cost of standard and carbide blades (including double-stacked blades and additional middle guards) are calculated using pricing from 2012 to 2014.

# The Ohio Department of Transportation

## Year One

Specialty Blade	Specialty Quantity	Specialty Cost	Standard Quantity	Standard Cost	Savings per Blade
Carbide Single	1	\$836	1.7	\$916	\$80
JOMA	1	\$3,402	5	\$2,695	(\$707)
PolarFlex	1	\$2,507	4.5	\$2,424	(\$83)
Standard	1	\$539	1	\$539	\$0
XL Classic	1	\$3,021	6.6	\$3,554	\$534

Note: The savings represents the cost savings per one specialty blade. Maintenance costs for blade changes are included in these costs.

## Year Two

Specialty Blade	Specialty Quantity	Specialty Cost	Standard Quantity	Standard Cost	Savings per Blade
Carbide Single	1	\$836	1.5	\$807	(\$29)
Carbide Double	1	\$1,416	2.9	\$1,561	\$145
Double Stack	1	\$745	1.9	\$1,023	\$278
Middle Guard	1	\$648	1.9	\$1,023	\$375
No Counterbalance	1	\$539	0.8	\$432	(\$107)
PolarFlex	1	\$2,507	9.4	\$5,061	\$2,554
Standard	1	\$539	1	\$539	\$0
XL Classic	1	\$3,021	7.7	\$4,145	\$1,125

Note: The savings represents the cost savings associated with one specialty blade. Maintenance costs for blade changes are included in these costs. "No Counterbalance" is a standard blade on a truck with no counterbalance.

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## Year One & Two

Specialty Blade	Specialty Quantity	Specialty Cost	Standard Quantity	Standard Cost	Savings per Blade
Carbide Single	1	\$836	1.5	\$807	(\$29)
PolarFlex	1	\$2,507	6.1	\$3,285	\$778
Standard	1	\$539	1	\$539	\$0
XL Classic	1	\$3,021	6.4	\$3,447	\$426

Note: The savings represents the cost savings associated with one specialty blade. Maintenance costs for blade changes are included in these costs.

Year One Data			Year Two Data			Year One and Two Data		
Blade	Rank	Cost Savings when compared to Equivalent Standard Blades	Blade	Rank	Cost Savings when compared to Equivalent Standard Blades	Blade	Rank	Cost Savings when compared to Equivalent Standard Blades
XL Classic	1	\$534	PolarFlex	1	\$2,554	PolarFlex	1	\$778
Carbide Single	2	\$80	XL Classic	2	\$1,125	XL Classic	2	\$426
Standard	3	\$0	Middle Guard	3	\$375	Standard	3	\$0
PolarFlex	4	-\$83	Double Stack	4	\$278	Carbide Single	4	-\$29
JOMA	5	-\$707	Carbide Double	5	\$145			
			Standard	6	\$0			
			Carbide Single	7	-\$29			
			No Counterbalance	8	-\$107			

Note: A number 1 rank means the most cost savings per blade implemented in place of a standard blade. If a blade is below the standard blade rank, there is a cost associated with implementing that blade instead of a standard blade and will be denote with a negative sign on the cost.

# The Ohio Department of Transportation



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