

A map of Michigan showing county boundaries and names. The map is semi-transparent and serves as a background for the text. The title is centered at the top. A red horizontal line is positioned below the title. The text is located in the lower-left quadrant of the slide.

Center of Energy Excellence Feedstock Supply Chain Models

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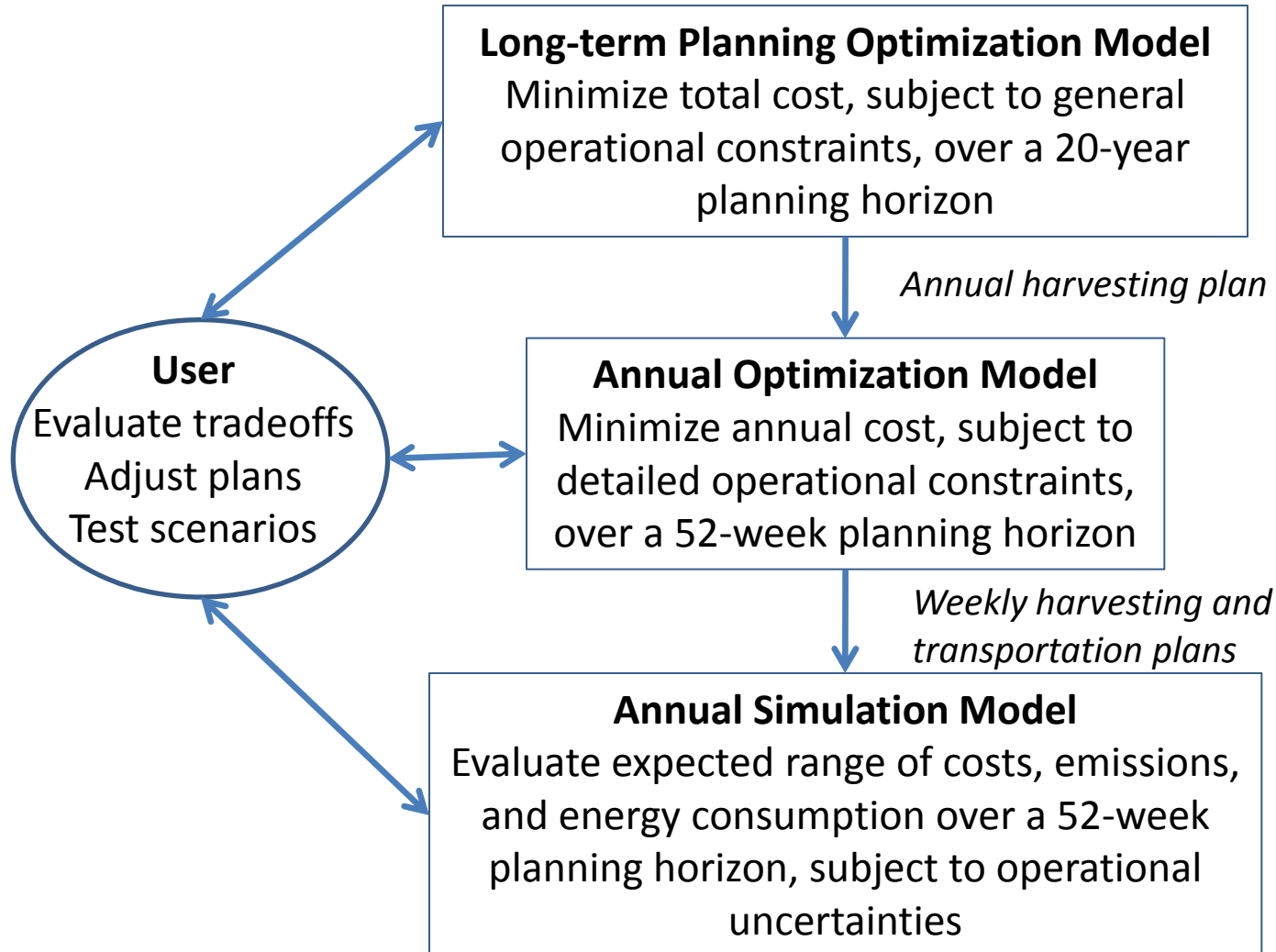
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Acknowledgments: Christopher Peterson (MSU), William Knudson (MSU), Mark Johnson (MTU)

Role of Modeling

- To support development of an efficient supply chain for the Kinross Frontier facility
- Efficiency in this context is:
 - Supply sufficient fiber
 - Maintain reliable supply through spring “break-up”
 - Minimize cost of harvesting and delivering the fiber
 - Minimize/limit energy consumption and CO₂ emissions
 - Maintain supply chain reliability under a range of “likely” management scenarios
 - Recognize different behaviors by different land owners
 - Recognize different harvest costs for different levels of harvest intensity and site difficulty

Decision Support Modeling Framework



Data Sources for the Optimization Model

- Timber availability data from the MSU Project 2/Tessa Systems report
- Land base split into 4 ownerships
 - Federal (mostly Forest Service)
 - State (mostly DNR)
 - Private corporate/REIT/TIMO
 - Private small non-industrial
- Land base subdivided into 4 harvest cost categories
 - Clearcut - least expensive (aspen)
 - Shelterwood - second least expensive (oak)
 - Northern hardwoods – more expensive (normal & difficult sites)
- Harvest costs from MSU Project 3
- Transportation costs from MTU Project 3

Available Fiber Calculations

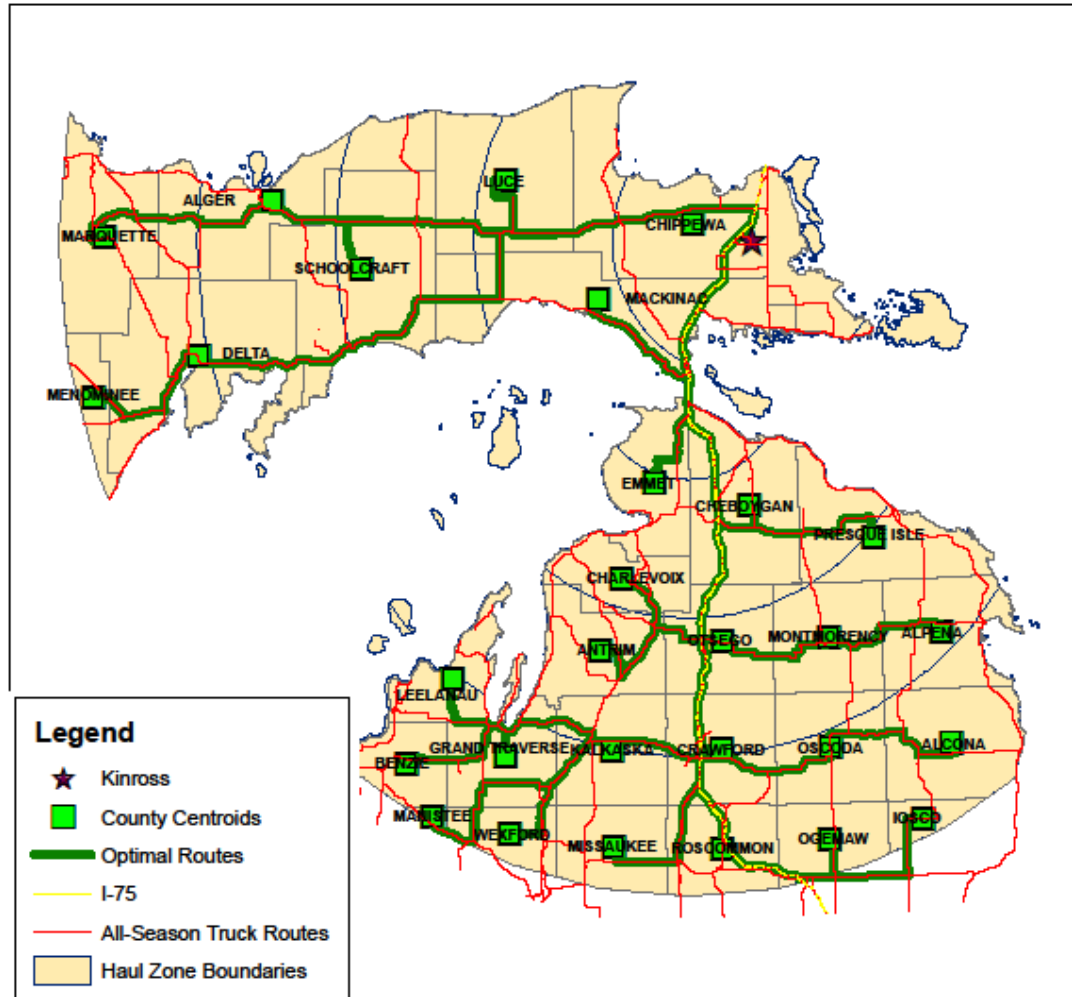
- Forest Inventory and Analysis data provided by MSU Project 2
 - Growth summarized for each
 - County
 - Haul zone
 - Ownership
 - Harvest cost category
 - Each of these combinations enters the model as a constraint

Transportation Distance Calculations

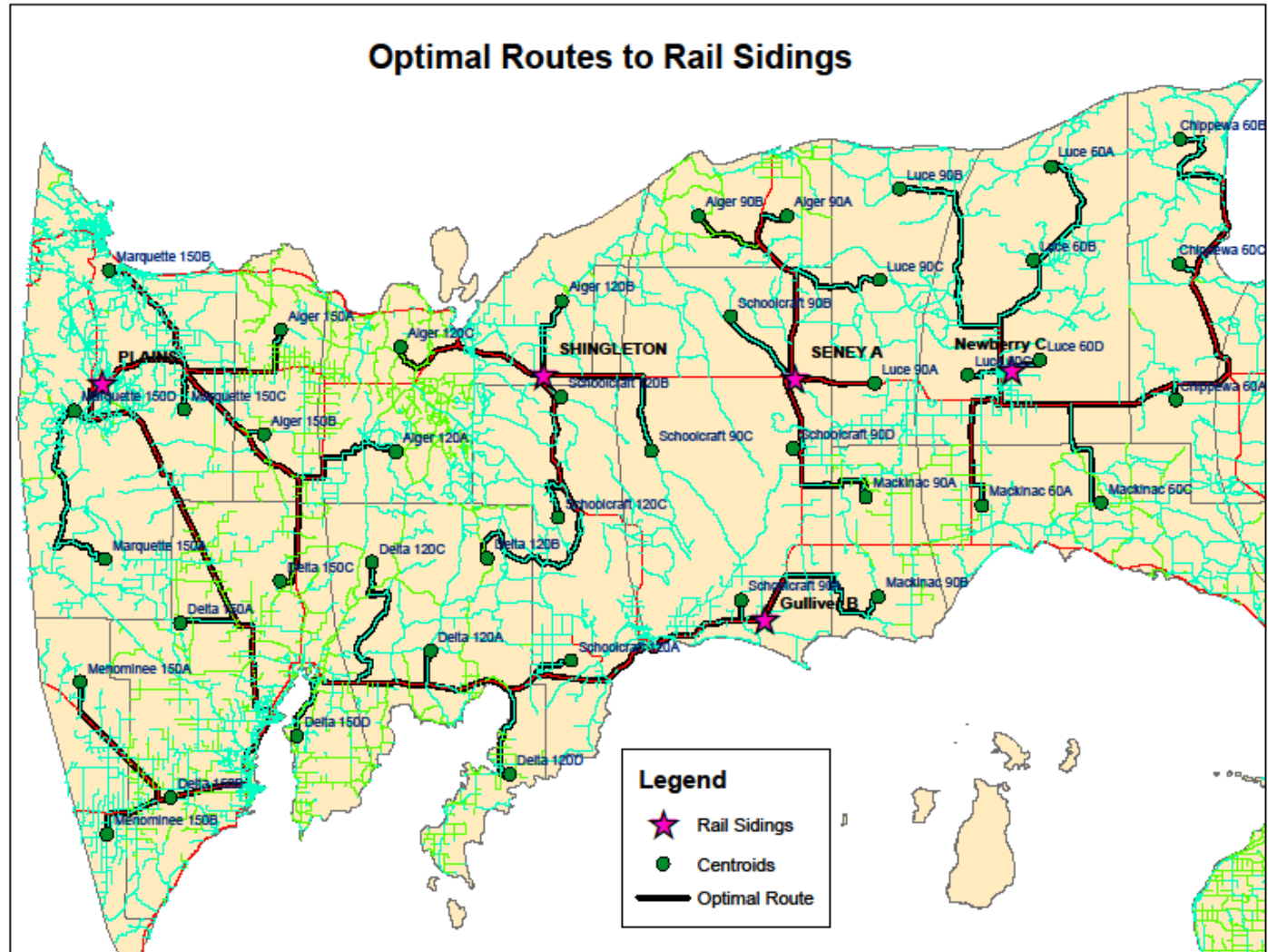
- Distance to facility was calculated from generated points
- Mileages were calculated for Class A highways, other public roads, and woods roads
 - Data layer of public roads provided by MTU Project 3
 - Woods roads were determined by inspection of air photos and USGS quad maps
 - A likely road path was selected from the closest woods road

Transportation Routes and Distances

Optimal Haul Routes from County Centroids



Transportation Routes and Distances



The Optimization User Interface

- Uses an Excel spreadsheet
- Allows fundamental data to be altered easily as new information becomes available
 - e. g., harvest cost data
- Allows scenario analysis by user
 - Impact of different harvest decisions by owners
 - Availability of wood delivered by rail from greater than 150 miles

Overview of the Simulation Model

- 43 harvest areas based on the intersection of 29 counties and 30-mile-radius haul zones and 3 harvest areas farther than 150 miles;
 - Simulates daily supply chain operations for a 1-year duration;
- Simulation is driven by the daily demand of the facility (“pull”) and a specified harvest plan (“push”).
 - The facility requests logs from log yards or roadside storage;
 - All harvested logs assumed to “pass through” roadside storage;
- Transporters (trucks/railcars) are dispatched according to daily feedstock demand;
 - Three types of transporters: rail, truck in U.P., and truck in L.P.;

Inputs to the Simulation Model

- Model inputs include:
 - Transportation and harvesting plans
 - Transportation and storage costs
 - Mill/log yards capacity data
 - Emissions and energy consumption rates
 - Spring breakup start day and end day
 - Either read in from Excel file or simulated by the model based on the user-specified distributions of start day and end day;
- Input data are either in an Excel file or in a data entry window that appears before the model runs.

Input: Data Entry Window

Parameter setting

The parameters can be initialized for the simulation run.

Cost of transportation	
Variable mileage cost, log trucks	0.088 \$/ton-mile
Fixed cost, log trucks (includes one load/unload routine)	3.72 \$/ton
additional load/unload routine	3.4 \$/ton
variable mileage cost, rail transportation >100miles	0.039 \$/ton-mile
variable mileage cost, rail transportation <100miles	0.0065 \$/ton-mile
Fixed cost, rail transportation	6.54 \$/ton

Transportation	
truck capacity in Upper	55 tons
truck capacity in Lower	50 tons
Rail car capacity	80 tons
Number of rail cars per rail trip	4

Mill	
Daily Production demand	3200 tons
Target Stock of mill log yard before/ during Spring Breakup	180000 tons
Target Stock of mill log yard for remaining time	80000 tons
Reorder Level Stock of mill log yard	12000 tons
Annual Storage Cost at Mill	50000 \$/year
Mill Initial Inventory	60000 tons
Average Age for Mill Initial Inventory	5 days
Mill Capacity	200000 tons

To Select Locations of Log Yards

Spring Breakup

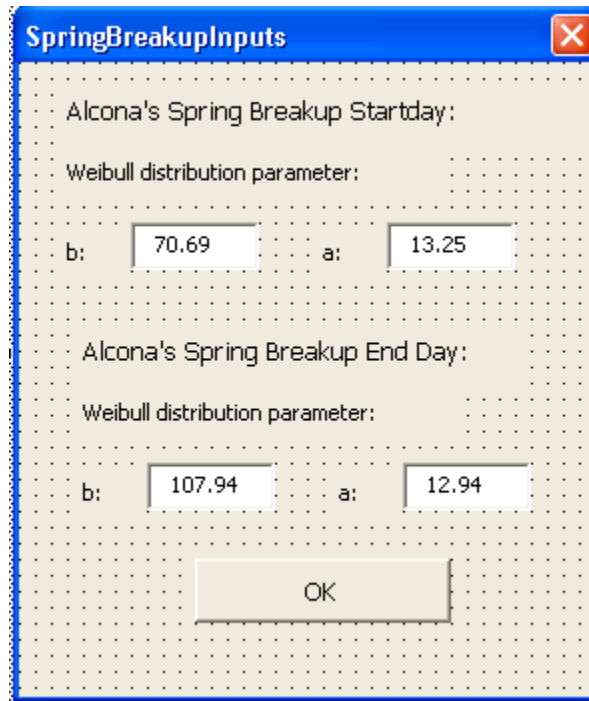
Reading from Excels file according to Alcona's input

OK

Two ways to input spring breakup data

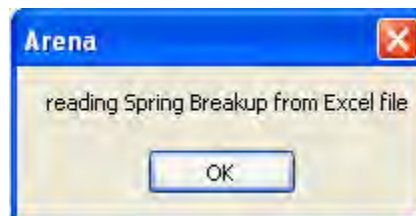
Input: Data Entry Window

If the second option is chosen, another box opens:



The image shows a dialog box titled "SpringBreakupInputs" with a blue title bar and a close button. The dialog is set against a dotted background. It contains two sections for data entry. The first section is for "Alcona's Spring Breakup Startday:" and includes a label "Weibull distribution parameter:" followed by two input fields: "b:" with the value "70.69" and "a:" with the value "13.25". The second section is for "Alcona's Spring Breakup End Day:" and includes a label "Weibull distribution parameter:" followed by two input fields: "b:" with the value "107.94" and "a:" with the value "12.94". At the bottom center of the dialog is an "OK" button.

If no option is chosen, a warning shows up. The default option is reading data from the Excel file:



The image shows a small dialog box titled "Arena" with a blue title bar and a close button. The dialog has a light beige background and contains the text "reading Spring Breakup from Excel file". At the bottom center is an "OK" button.

Input: Excel Spreadsheet

Harvesting Plan

From optimization model

Logs	Harvest Area #1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13	#14	#15
production (50 tons /week)	Alcona 150	Alger 120	Alger 150	Alger 90	Alpena 120	Alpena 150	Antrim 120	Benzie 150	Charlevoix 90	Cheboygan 90	Chippewa 30	Chippewa 60	Crawford 120	Crawford 150	Delta 120
Week 1	26.4	31.1	11.3	10.5	8.0	4.1	20.7	9.8	17.6	23.8	30.4	18.3	5.4	6.4	21.3
Week 2	26.4	31.1	11.3	10.5	8.0	4.1	20.7	9.8	17.6	23.8	30.4	18.3	5.4	6.4	21.3
Week 3	26.4	31.1	11.3	10.5	8.0	4.1	20.7	9.8	17.6	23.8	30.4	18.3	5.4	6.4	21.3
Week 4	26.4	31.1	11.3	10.5	8.0	4.1	20.7	9.8	17.6	23.8	30.4	18.3	5.4	6.4	21.3
Week 5	26.4	31.1	11.3	10.5	8.0	4.1	20.7	9.8	17.6	23.8	30.4	18.3	5.4	6.4	21.3
Week 6	26.4	31.1	11.3	10.5	8.0	4.1	20.7	9.8	17.6	23.8	30.4	18.3	5.4	6.4	21.3

Transportation Plan

Regular transportation plan	LP	UP	UP	UP	LP	LP	LP	LP
	#1	#2	#3	#4	#5	#6	#7	#8
Week 1	3	4	3	4	2	2	3	3
Week 2	3	4	3	4	2	2	3	3
Week 3	3	4	3	4	2	2	3	3
Week 4	3	4	3	4	2	2	3	3
Week 5	3	4	3	4	2	2	3	3
Week 6	3	4	3	4	2	2	3	3
Week 7	3	4	3	4	2	2	3	3
Week 8	3	4	3	4	2	2	3	3
Week 9	3	4	3	4	2	2	3	3

Spring Breakup

	Harvesting Area	Daily Logs Production in Spring Break-up (50 tons/week)	1 Historic Start Date
1	Alcona 150	2.1	68
2	Alger 120	2.5	76
3	Alger 150	0.9	76
4	Alger 90	0.8	76
5	Alpena 120	0.6	68
6	Alpena 150	0.3	68
7	Antrim 120	1.7	68

Harvesting, transportation, and storage costs

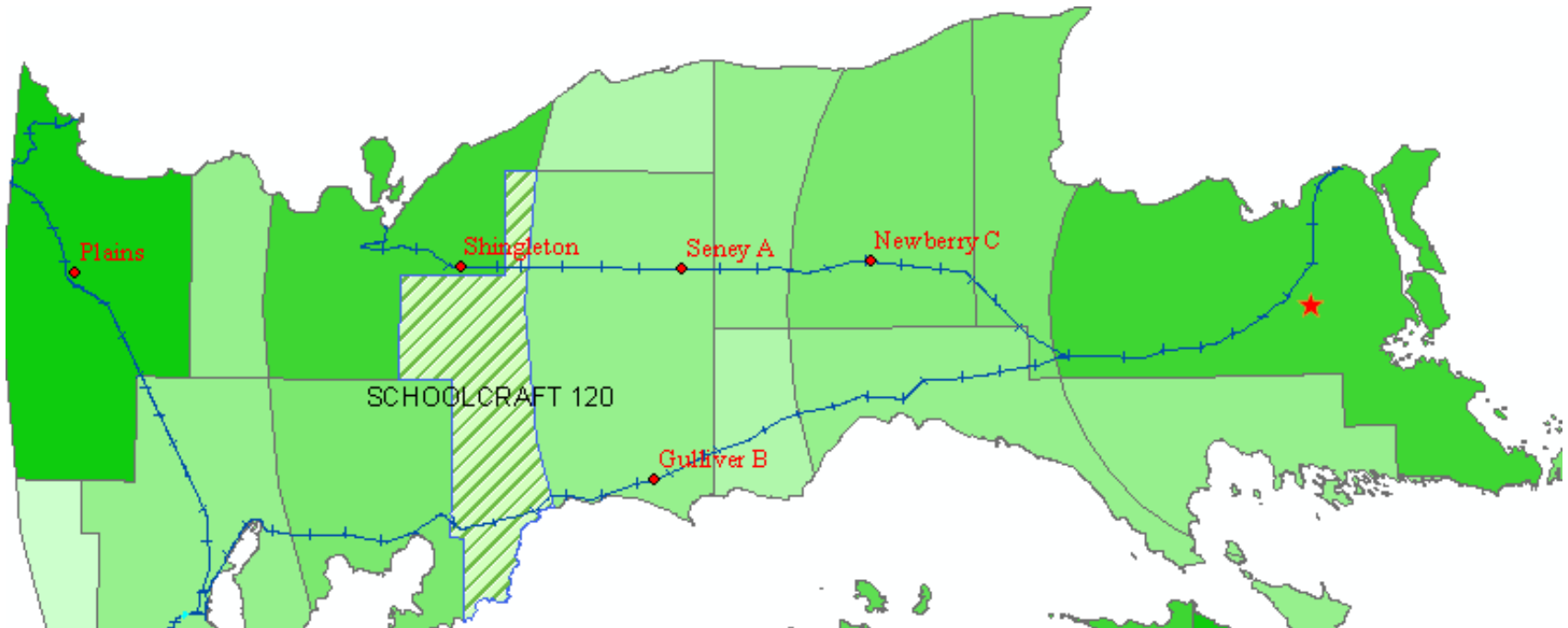
Transportation (network) distances

Roadside, log yards, and mill yard storage capacities

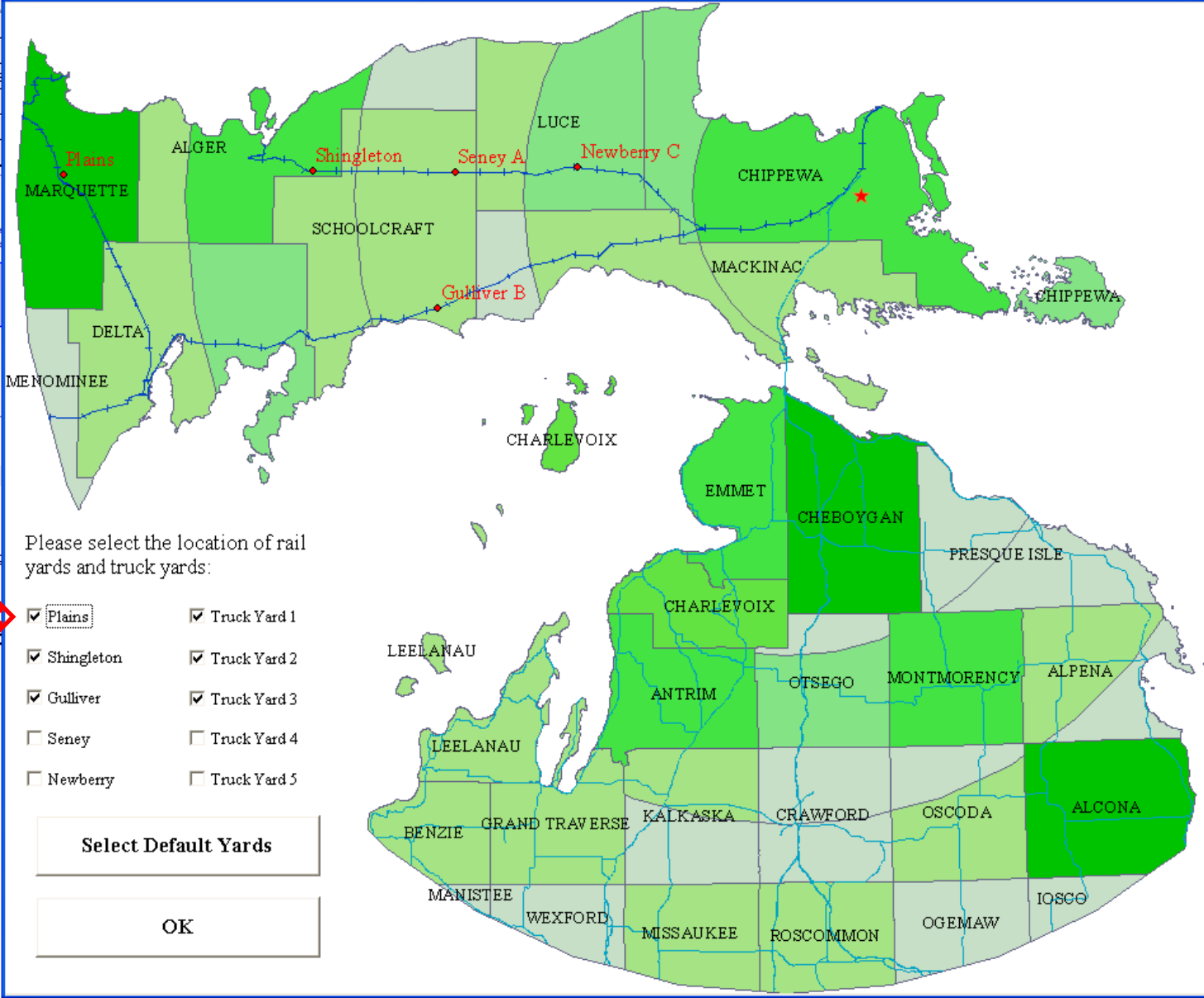
Initial, target, and reorder inventory levels

Energy use and emissions data

User Input: Select Log Yards



Locations of Yards



Please select the location of rail yards and truck yards:

- | | |
|--|--|
| <input checked="" type="checkbox"/> Plains | <input checked="" type="checkbox"/> Truck Yard 1 |
| <input checked="" type="checkbox"/> Shingleton | <input checked="" type="checkbox"/> Truck Yard 2 |
| <input checked="" type="checkbox"/> Gulliver | <input checked="" type="checkbox"/> Truck Yard 3 |
| <input type="checkbox"/> Seney | <input type="checkbox"/> Truck Yard 4 |
| <input type="checkbox"/> Newberry | <input type="checkbox"/> Truck Yard 5 |

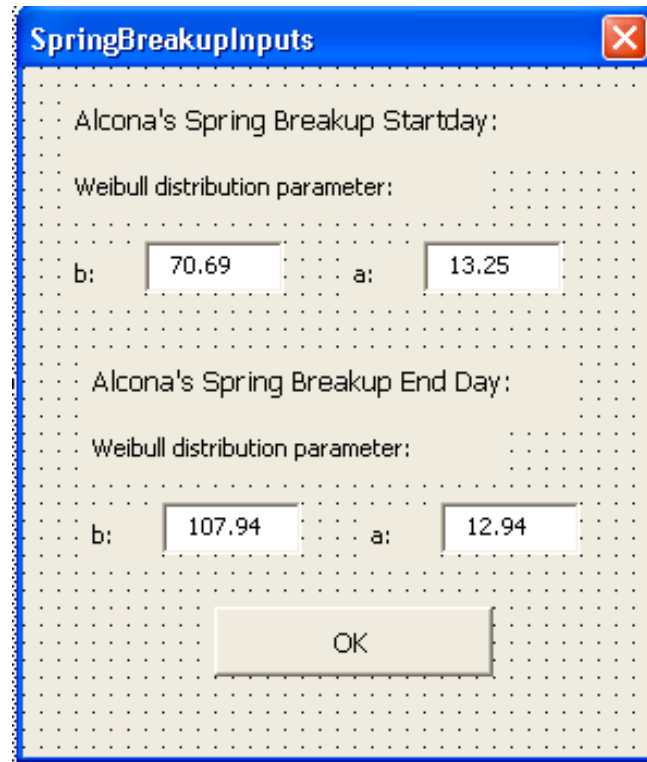
Select Default Yards

OK



User Input: Spring Break-up Parameters

- The distribution for start day and end day of spring breakup in Alcona County;



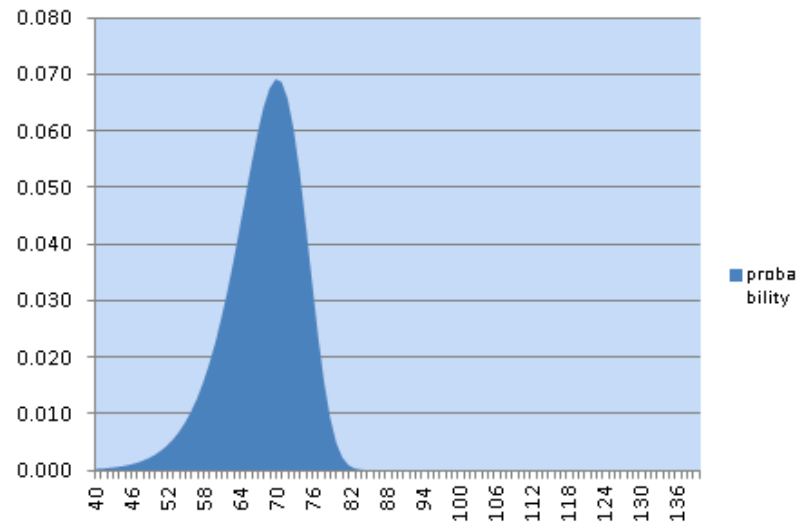
A screenshot of a Windows-style dialog box titled "SpringBreakupInputs". The dialog box has a blue title bar with a close button (X) in the top right corner. The background is a light gray grid. The dialog contains two sections for inputting Weibull distribution parameters. The first section is for "Alcona's Spring Breakup Startday:" and includes a label "Weibull distribution parameter:" followed by two input fields: "b:" with the value "70.69" and "a:" with the value "13.25". The second section is for "Alcona's Spring Breakup End Day:" and includes a label "Weibull distribution parameter:" followed by two input fields: "b:" with the value "107.94" and "a:" with the value "12.94". At the bottom center of the dialog is an "OK" button.

Parameter	b	a
Alcona's Spring Breakup Startday	70.69	13.25
Alcona's Spring Breakup End Day	107.94	12.94

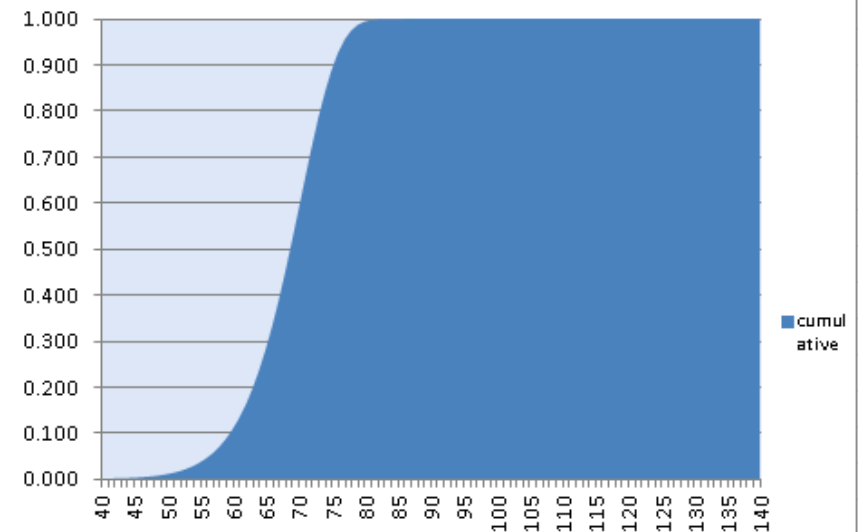
Weibull Distribution

Probability Density Function and Cumulative Distribution Function

probability density function



cumulative distribution function



13.256 a shape parameter

70.69 b scale parameter

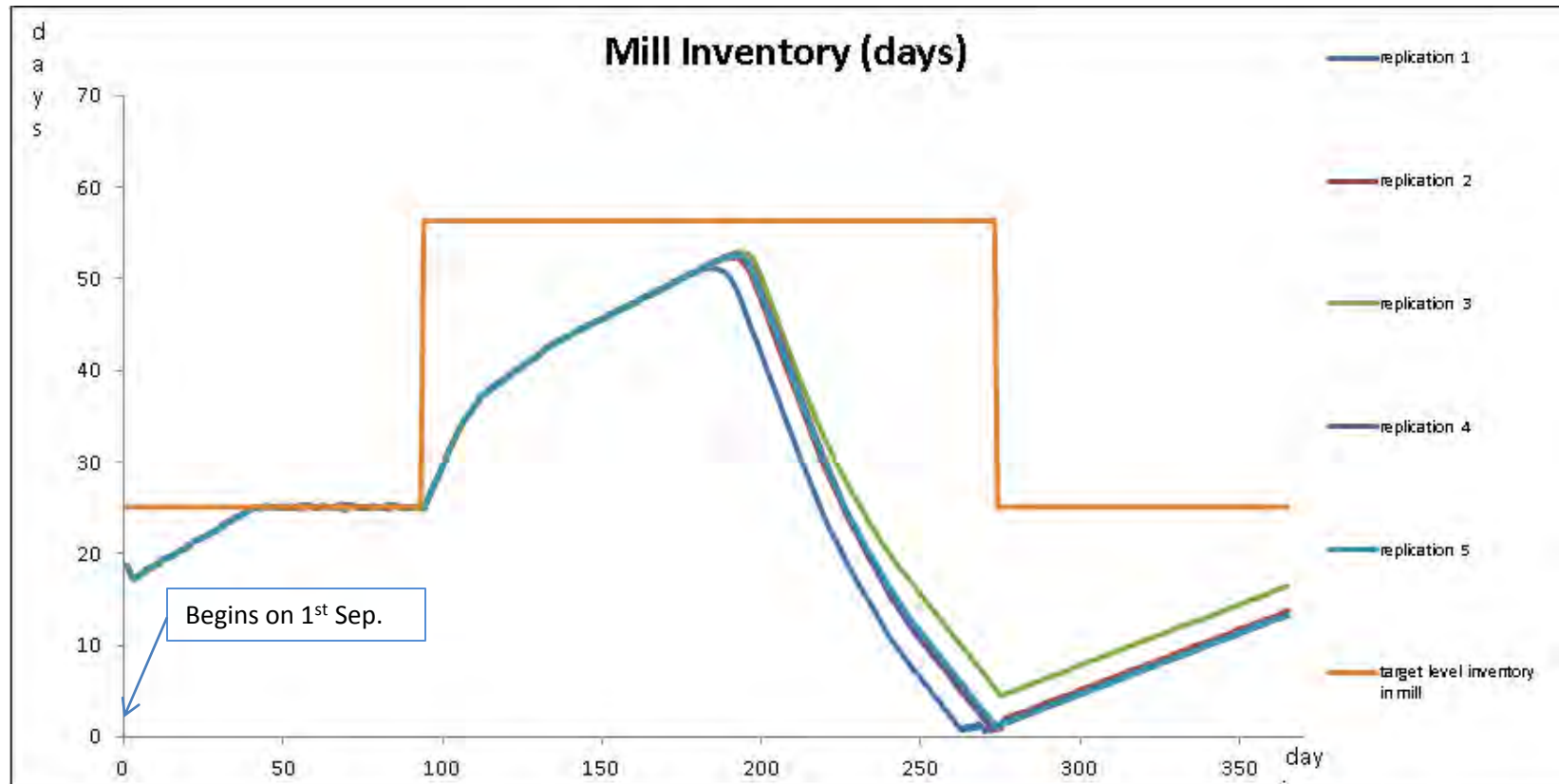
County	Year	End day	Start Day
Alcona	2010	98	62
	2009	118	68
	2008	120	77
	2007	116	71
	2006	108	68
	2005	110	73
	2004	111	61
	2003	119	74
	2002	115	52
	2001	114	67

The parameters $a=13.256$, $b=70.6925$ for start day and $a=12.94$, $b=107.94$ for end day in Alcona are developed based on historical data by Matlab.

Simulation Model Outputs

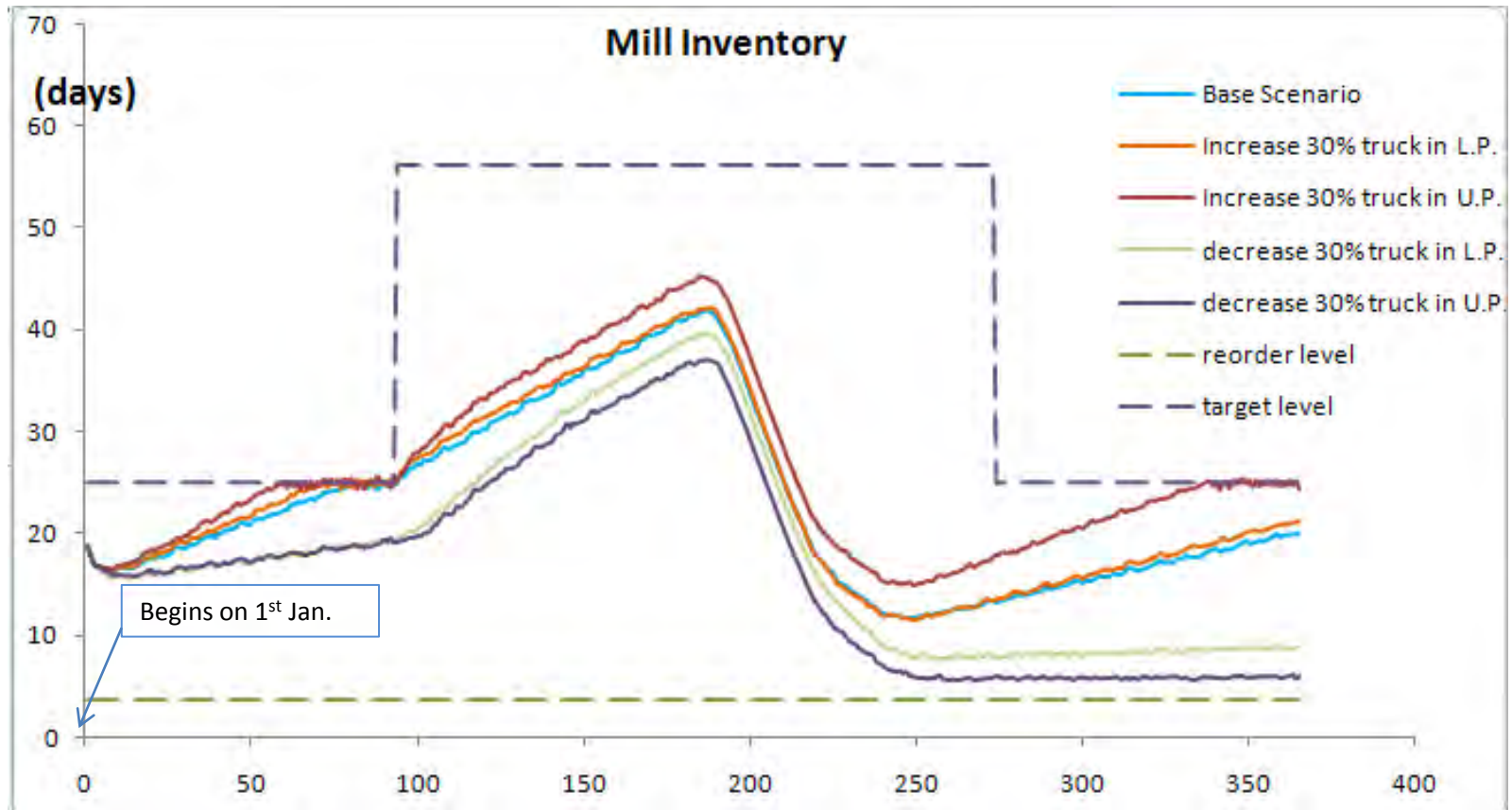
- Model outputs include, but are not limited to:
 - Daily inventory of the facility yard, roadside storage areas, and log yards.
 - Time series and total annual system cost, fuel usage, and emissions.
 - Transportation statistics.
 - Record of average and maximum log ages processed at the facility.

Example Output Time Series



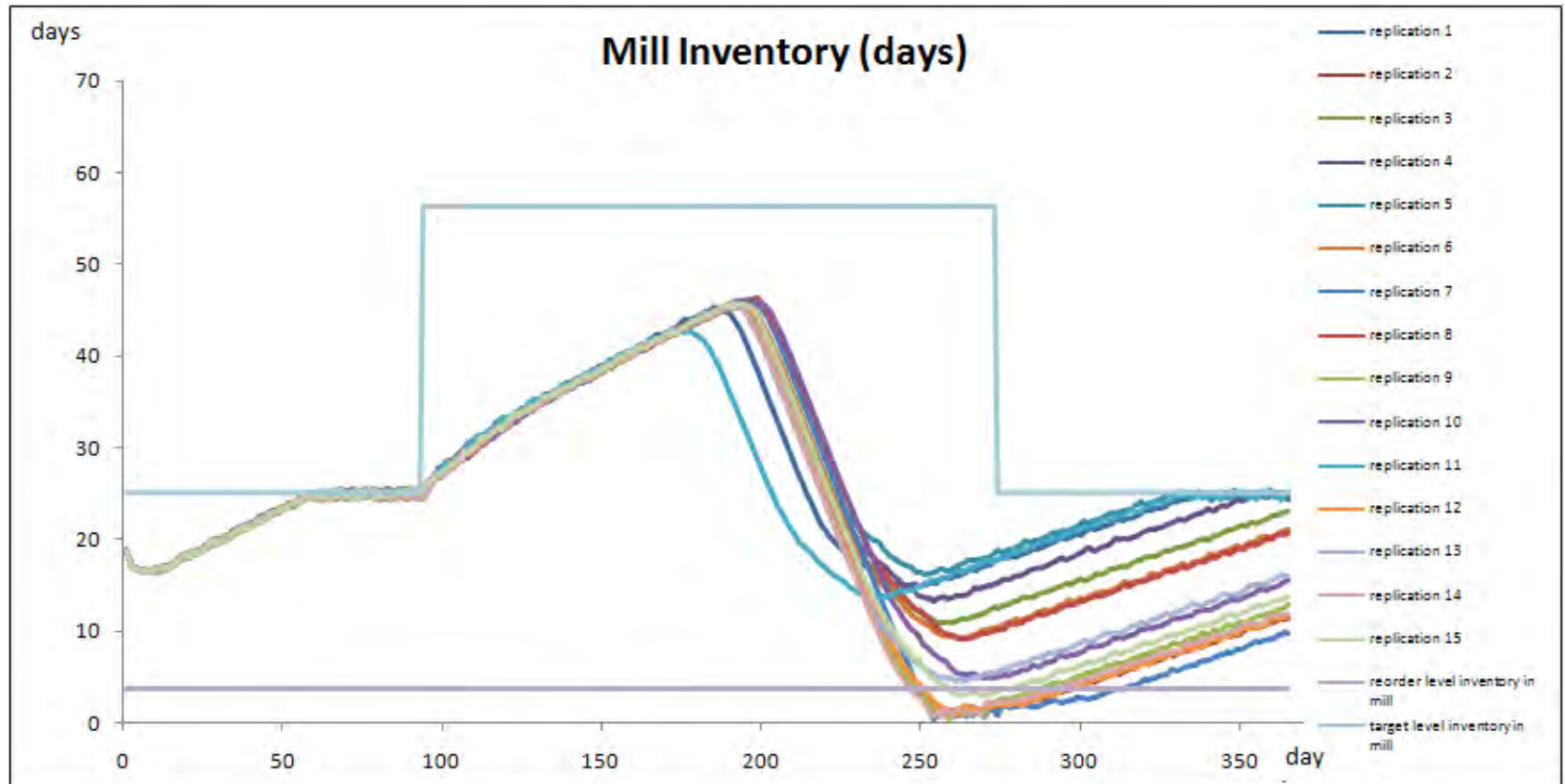
Inventory at the facility/mill (in days of supply) vs. Julian day for the baseline transportation plan under five scenarios of weather/spring break-up.

Scenario Analysis: Truck Availability



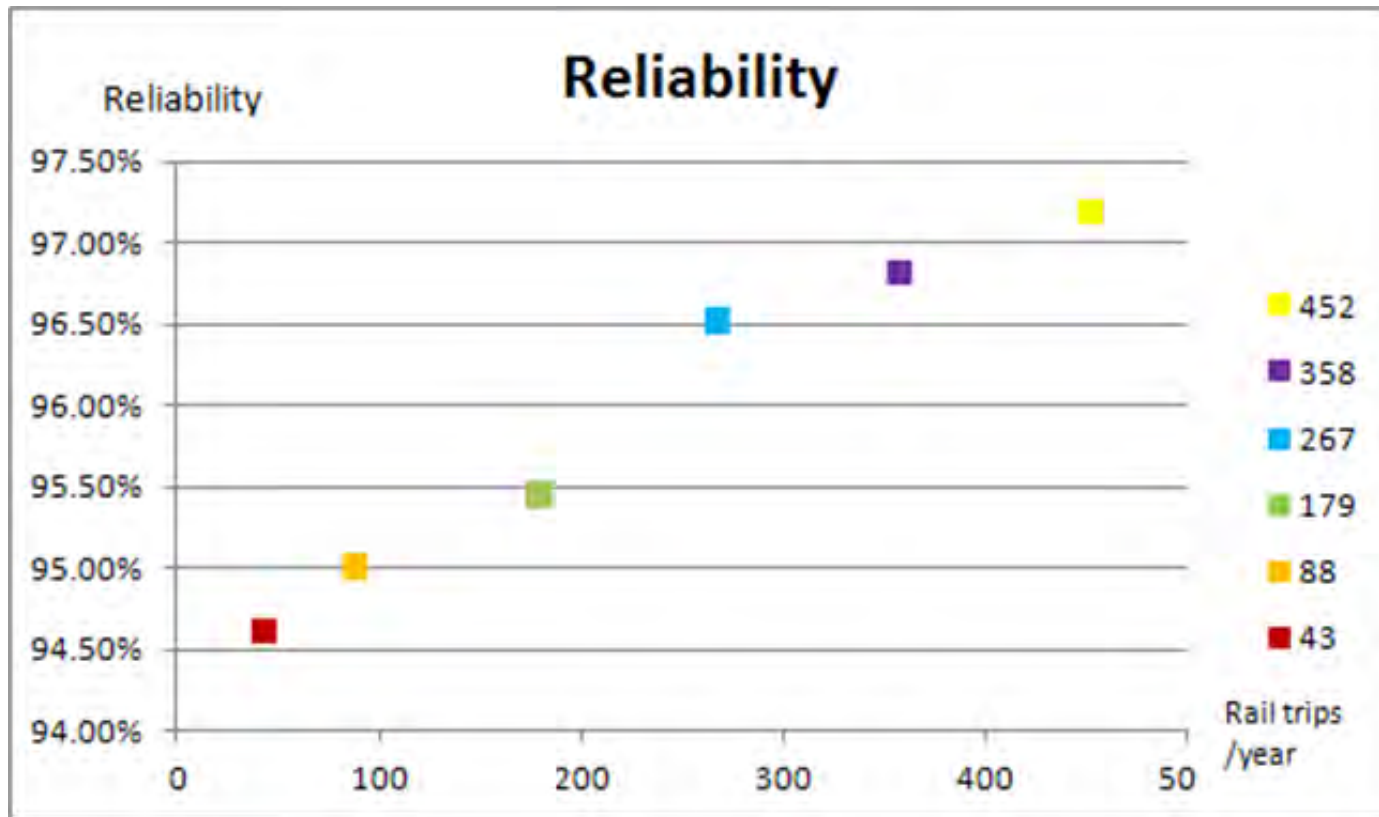
Inventory at the facility/mill (in days of supply) vs. Julian day for the baseline transportation plan under scenarios of truck availability.

Scenario Analysis: Spring Break-up Timing



Inventory at the facility/mill (in days) vs. Julian day for the baseline transportation plan under 15 spring break-up scenarios.

Trade-off Analysis: Reliability and Rail Use



Rail use vs. reliability of supply at the facility/mill. Assumes each rail trip has 4 railcars with 80 tons capacity per car,