

Type II Producer Data: Additional Analysis

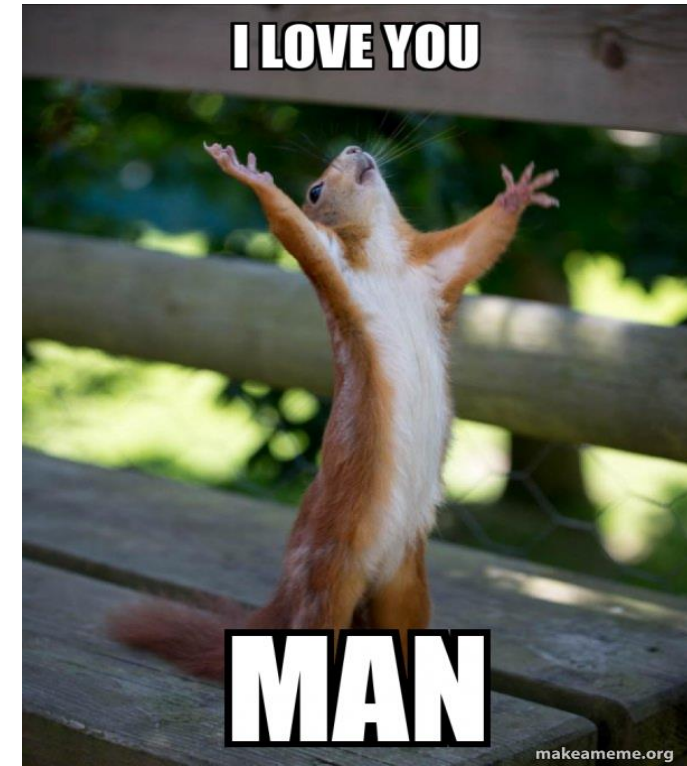
Larry Sutter Ph.D., P.E., F.ACI, F.ASTM

Principal
Sutter Engineering LLC
Houghton MI 49931

Professor Emeritus and Professor of Research
Materials Science & Engineering
Michigan Technological University, Houghton MI

NC² Study of AASHTO M 240/ASTM C595 Type IL Cement Properties

- The discussion of Type IL cement performance continues; variability is still a question for some
- All stakeholders want the same outcomes:
 - **Durable concrete with the lowest possible life-cycle cost**
- Concrete is still the answer; we just took a step backwards and now need to move forward
 - Rebuild the trust between the cement producers and the DOTs
 - Requires communication and transparency, some listening on both sides, and time



https://makeameme.org/meme/i-love-you-5d6b16aaf#google_vignette

NC² Study of AASHTO M 240/ASTM C595 Type IL Cement Properties

- The discussion of Type IL cement performance continues; variability is still a question for some
- All stakeholders want the same outcomes:
 - **Durable concrete with the lowest possible life-cycle cost**
- Concrete is still the answer; we just took a step backwards and now need to move forward
 - Rebuild the trust between the cement producers and the DOTs
 - Requires communication and transparency, some listening on both sides, and time



<https://www.campkumbayah.org>

Refresher

- At the NC² meeting held in Rosemont, Illinois, April 8 - 10, 2025, a half-day workshop on implementation of blended cements was held
- Some NC² stakeholders (e.g., SHAs and contractors) raised concerns over the variability in limestone content of Type IL cements
- Information on cement characteristics is limited for users; SHAs receive 30-day mill certifications, which are often delayed and do not reflect day-to-day variations
- Stakeholders felt that more complete data from producers AND data from DOTs/contractors on failures/problems is required

Refresher

- The NC² Chair sent a request to 23 cement companies identified from a review of the NC² states' approved product lists (APLs)
- In total across all companies, 82 cement plants were identified as having a Type IL cement listed on at least one state's APL
- 138 plant personnel were identified from the same scan of the APL data and were contacted
- The cement producers were requested to provide the following:

Refresher

On behalf of NC², the SHAs are collectively requesting Type IL cement data from all plants shown in Attachment 1, retroactive to January 1, 2022 through June 30, 2025, providing at a minimum the following information (for data available):

1. Bulk Shipping Sample Data (identify test methods used)
 - 3, 7, and 28-day compressive strength
 - Time of Set
 - Fineness
 - Loss on ignition
 - Sulfate Content (SO₃)
 - Limestone content
2. Monthly Composite Samples
 - 30-day published mill certifications data

NC² Study of AASHTO M 240/ASTM C595 Type IL Cement Properties

On behalf of NC², the SHAs are collectively requesting Type IL cement data from all plants shown in Attachment 1, retroactive to January 1, 2022 through June 30, 2025, providing at a minimum the following information (for data available):

1. Bulk Shipping Sample Data (identify test methods used)

- 3, 7, and 28-day compressive strength
- Time of Set
- Fineness
- Loss on ignition
- Sulfate Content (SO₃)
- Limestone content

2. Monthly Composite Samples

- 30-day published mill certifications data

Note: We were guided to ask for bulk shipping data by producers.

The thinking was it would best represent what was shipped, which may be different from what is produced on a given day, for many reasons (e.g., blending)

Companies Responding = 10

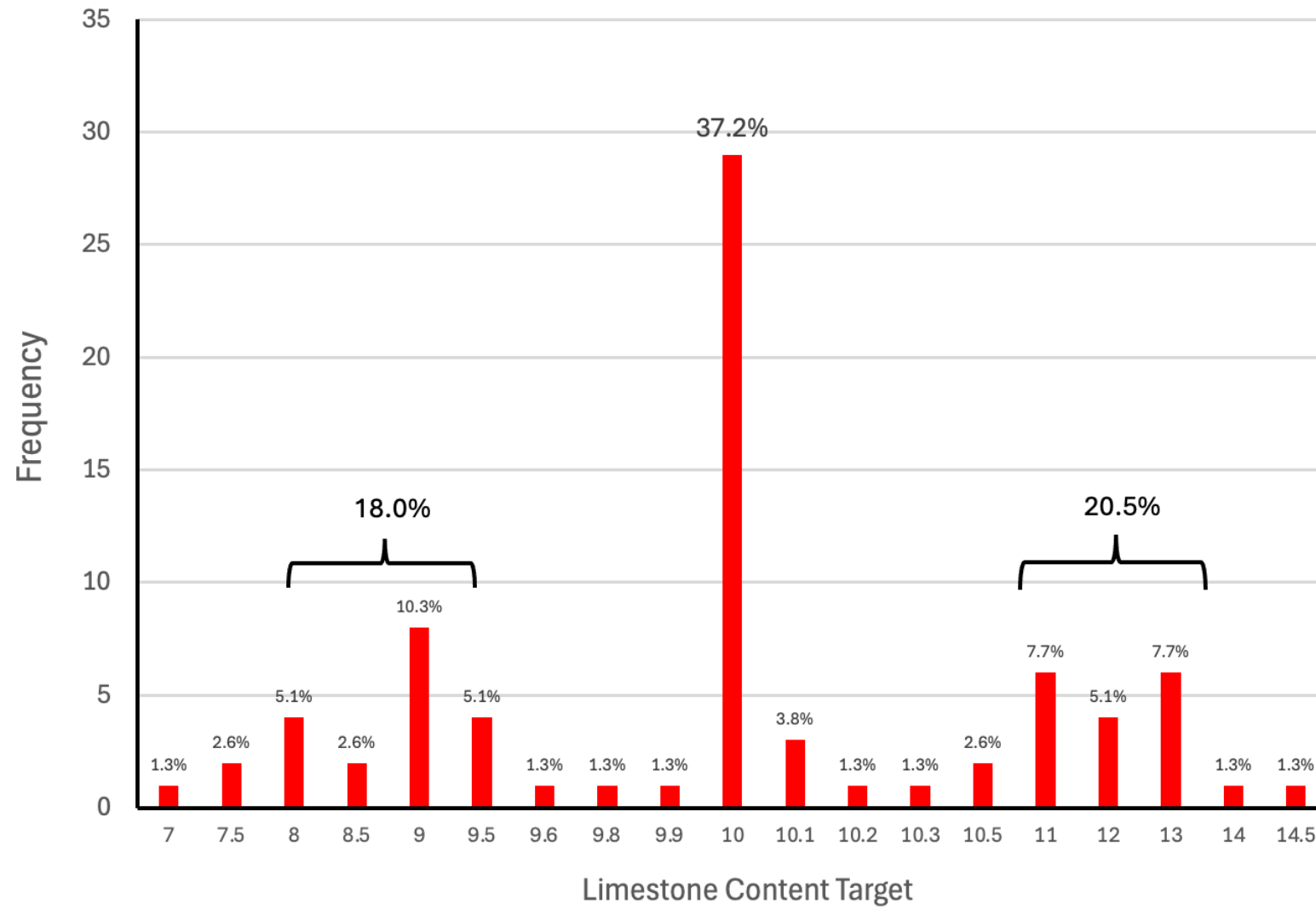
Companies responding with usable data = 8

- Amrize
- Ash Grove Cement
- CalPortland
- Cemex
- GCC
- Heidelberg Materials
- National Cement
- St Marys Cement

By the Numbers

- Total plants identified, all companies = **82**
- Total plants responding with usable data = **40** (49%)
- "Daily" data = 37 of 40 (93%)
- Mill Certs (published) = 29 of 40 (73%)
- Limestone Targets = 38 of 40 (95%)
- Reporting time periods ranged from less than one year to three years

Limestone Targets



ASTM C917 - Overview

- Used by U.S. cement producers for quality control, universally
- Only focusses on strength
- Could – through adoption of new tests - provide an opportunity for obtaining more data but Test Method C917 is currently not referenced by AASHTO or ASTM cement standards
- If modified – the important question is what to measure?
- Does limestone content alone tell us anything useful? If not, what is useful?

Common Available Cement Production Data

- **Monthly Composites** used for mill certs – from daily composites
- **Daily Composite** - composite of hourly samples taken for process control at the mill
 - SO_3 , Blaine, 325 mesh
- Daily composites are not universal across all plants; maybe analyzed for specification requirements (i.e., limestone) but not at all plants
- Daily composites represent production but not necessarily shipping; depends on the sample point, number of circuits in a mill being combined, blending stockpiled material, etc.

Issues

- We were told going in – and can confirm – there is no uniform approach to what is analyzed and how frequently
- Data received included bulk daily shipping, daily composite, and monthly composite
- In most cases, limestone is not analyzed on the bulk daily sample taken for ASTM C917 analysis
- **NOTE:** Data from DOTs and contractors regarding specific issues has not been provided

Data Analysis

- Daily data received for this study was primarily daily composite samples
- Some producers have limestone data from their ASTM C917 bulk shipping sample but must most do not
- This analysis is focusing on AASHTO M 240 & ASTM C595 limestone variability



Designation: C595/C595M – 24

Standard Specification for Blended Hydraulic Cements¹

15. Certification

15.3 At the request of the purchaser, the manufacturer shall also state in writing that the amounts of a constituent in the finished cement will not vary more than the percentages listed in **Table 5** with a 99 % probability of compliance between lots or **within a lot** (see **Note 12**).

- **Questions:** What is in Table 5? What is a “lot”? What is Note 12?

TABLE 5 Permitted Variation in Mass Percentage of Constituent

Constituent	Maximum Variation in Amount From Target, % by Mass of Blended Cement
Silica fume, metakaolin, limestone	± 2.5
All other constituents	± 5.0



Designation: C183/C183M – 22

Standard Practice for Sampling and the Amount of Testing of Hydraulic Cement¹

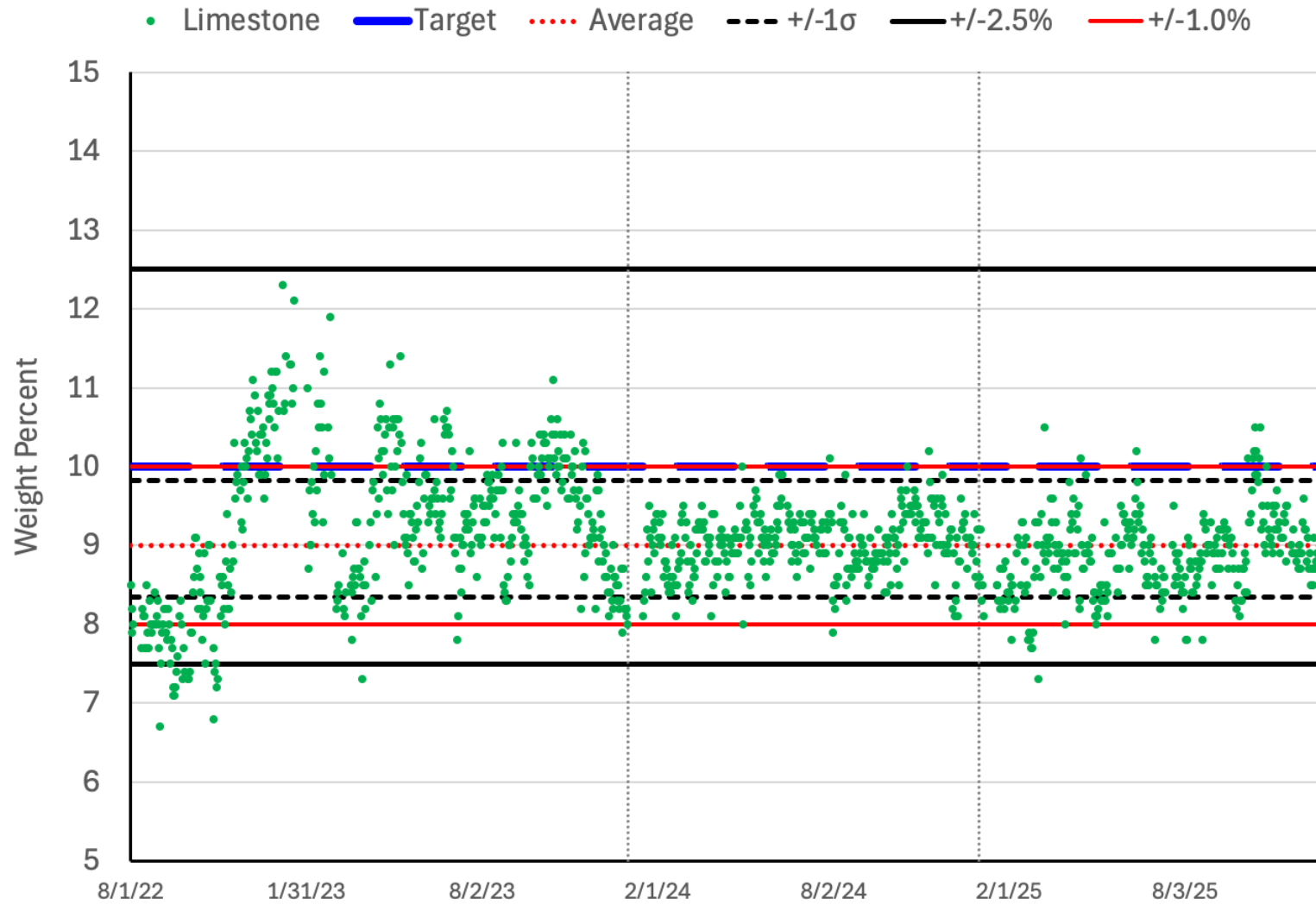
3.1.1 *lot (of cement), n*—specific quantity of cement offered for inspection at any one time. A lot may be one or more storage bins filled consecutively. A lot may also be the contents of one or more transport units representing cement drawn from the same storage bin.

NOTE 12—To satisfy the 99 % probability of compliance, the manufacturing process must be capable of producing a cement such that the standard deviation of the determined mass percentage of silica fume, metakaolin, or limestone in the cement is less than 1 %. For all other ingredients, the standard deviations of their determined mass percentages have to be less than 1.9 %. The variation in determined mass percentage includes that due to the amount and chemistry of the constituent, as well as that due to variation in verification testing. As an example, Type IP(5) made with silica fume indicates a blended hydraulic cement determined to contain between 2.5 % and 7.5 % silica fume by mass. A Type IP(20) cement made with fly ash indicates a blended cement determined to contain between 15 % and 25 % fly ash by mass.

NOTE 12—To satisfy the 99 % probability of compliance, the manufacturing process must be capable of producing a cement such that the standard deviation of the determined mass percentage of silica fume, metakaolin, or limestone in the cement is less than 1 %. For all other ingredients, the standard deviations of their determined mass percentages have to be less than 1.9 %. The variation in determined mass percentage includes that due to the amount and chemistry of the constituent, as well as that due to variation in verification testing. As an example, Type IP(5) made with silica fume indicates a blended hydraulic cement determined to contain between 2.5 % and 7.5 % silica fume by mass. A Type IP(20) cement made with fly ash indicates a blended cement determined to contain between 15 % and 25 % fly ash by mass.

Some example results to discuss

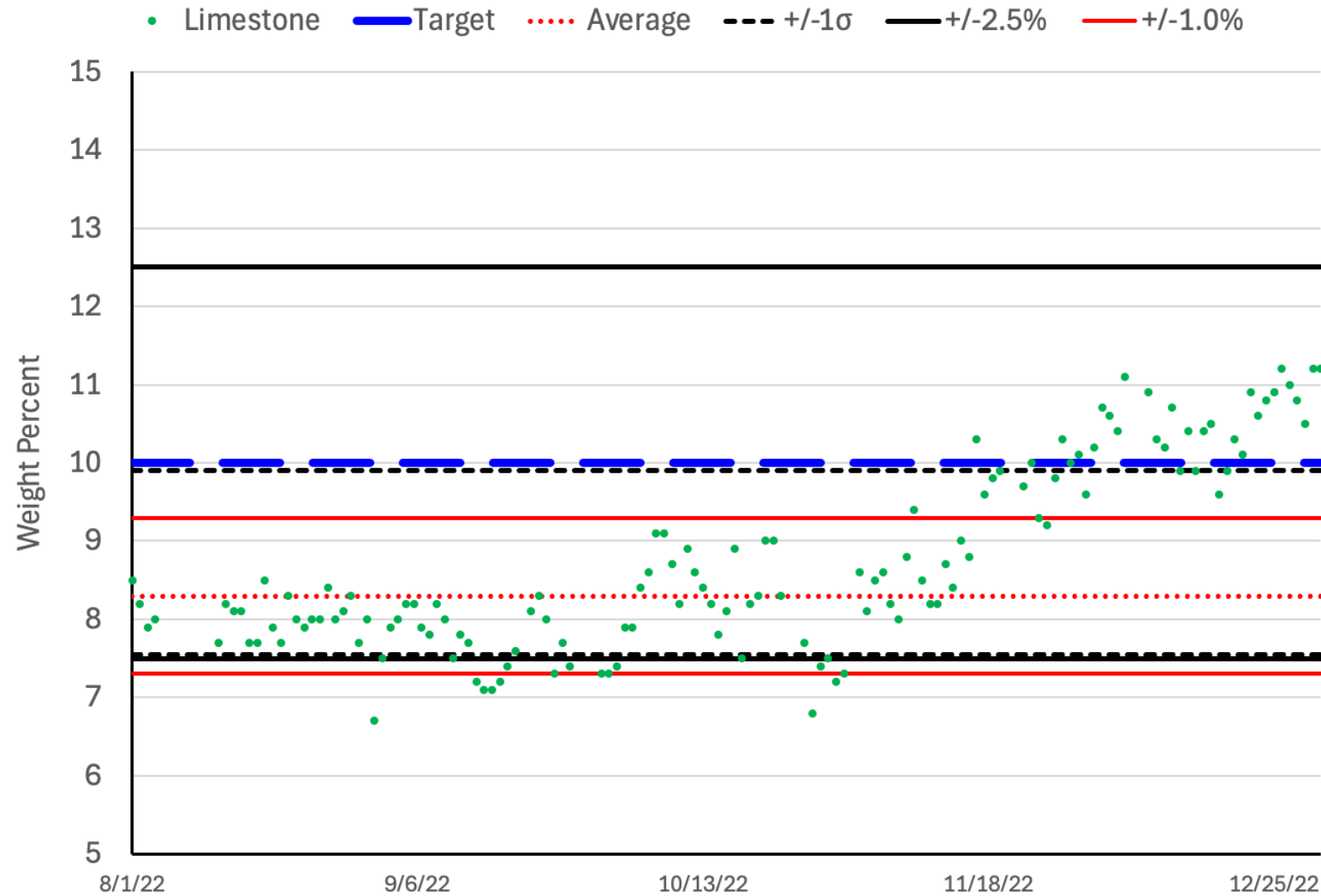
Plant 181 - Limestone



Min (%)	6.7
Max (%)	12.3
Median (%)	9
Average (%)	9.1
Std Dev	0.7
C of V	8.2%
+ 1 σ	9.8
- 1 σ	8.3
Percent within 2.5%	98.5%
Target	10%

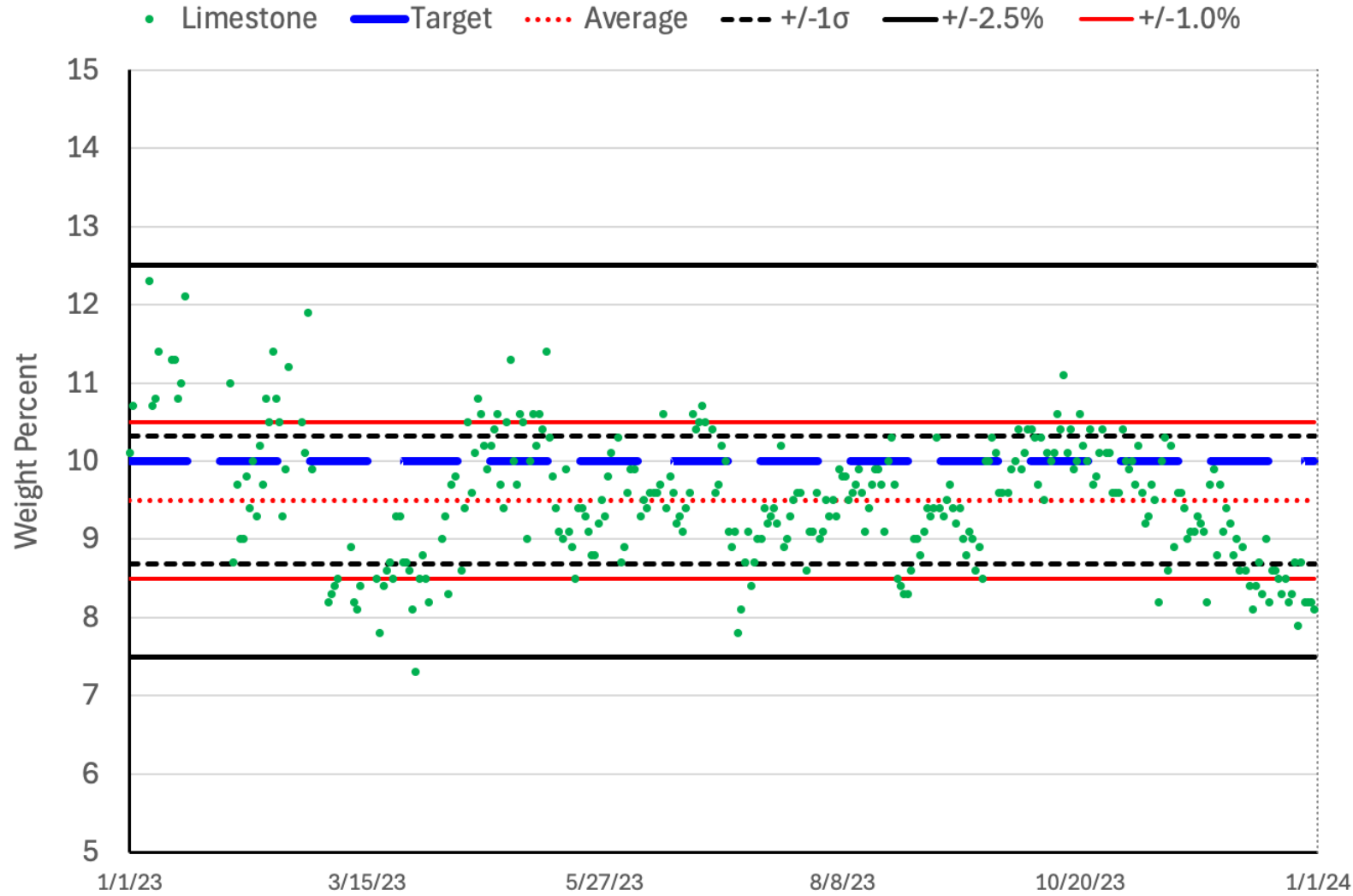
Plant 181 - Limestone

Year 1



Plant 181 - Limestone

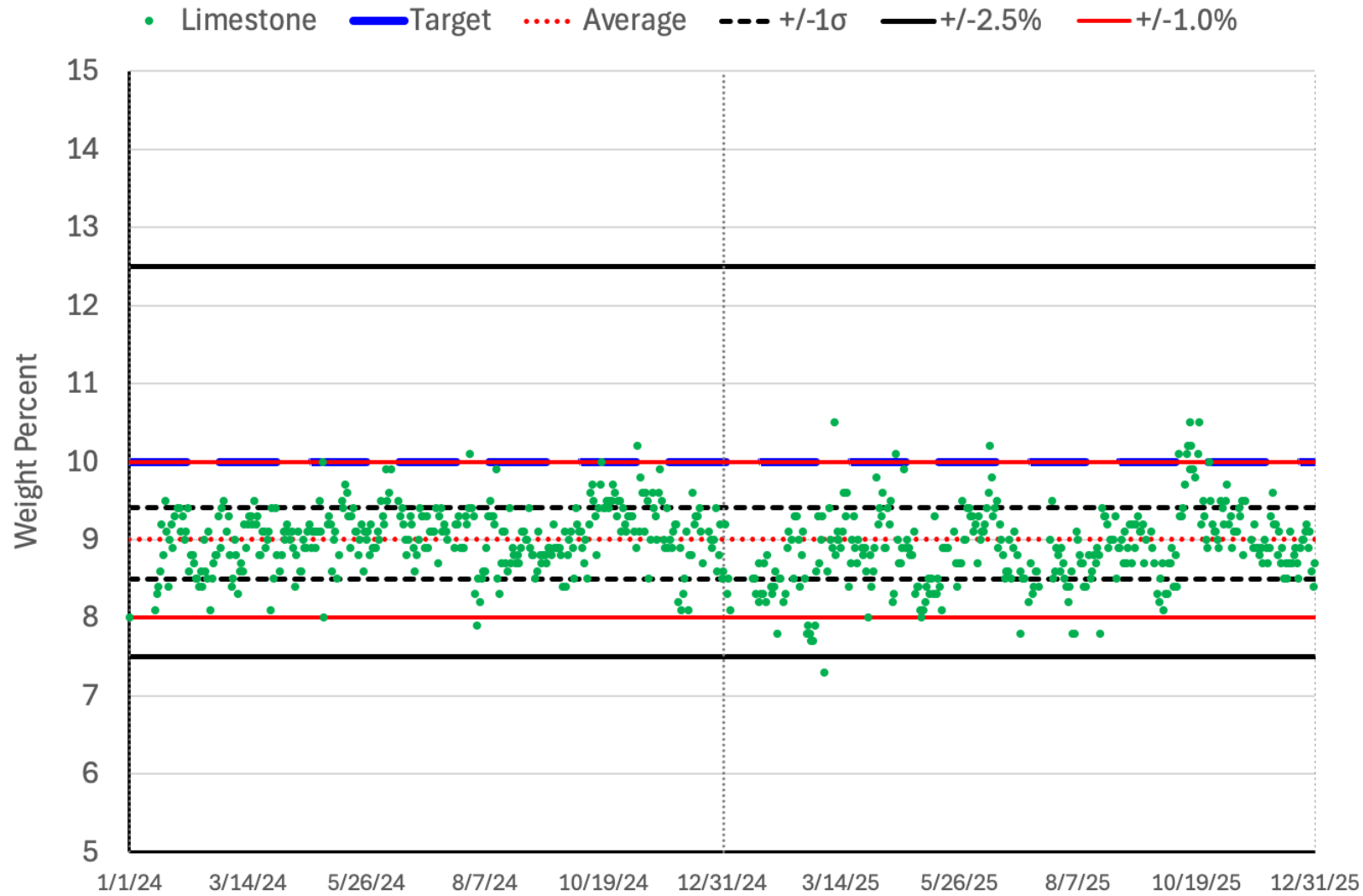
Year 2



Min (%)	7.3
Max (%)	12.3
Median (%)	9.5
Average (%)	9.5
Std Dev	0.8
C of V	8.6%
+ 1σ	10.3
- 1σ	8.7
Percent within 2.5%	99.7%
Target	10%

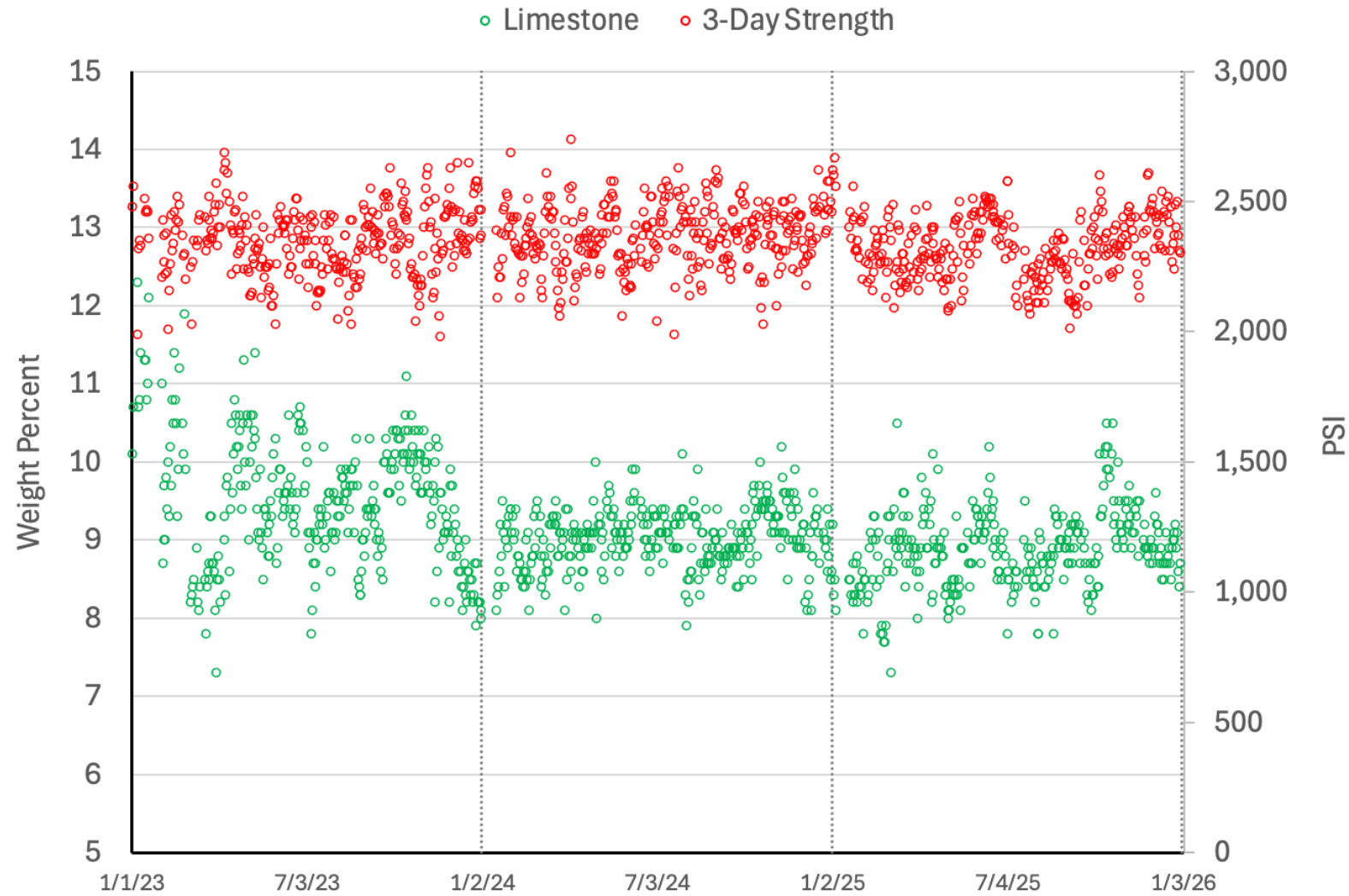
Plant 181 - Limestone

Year 3 & 4

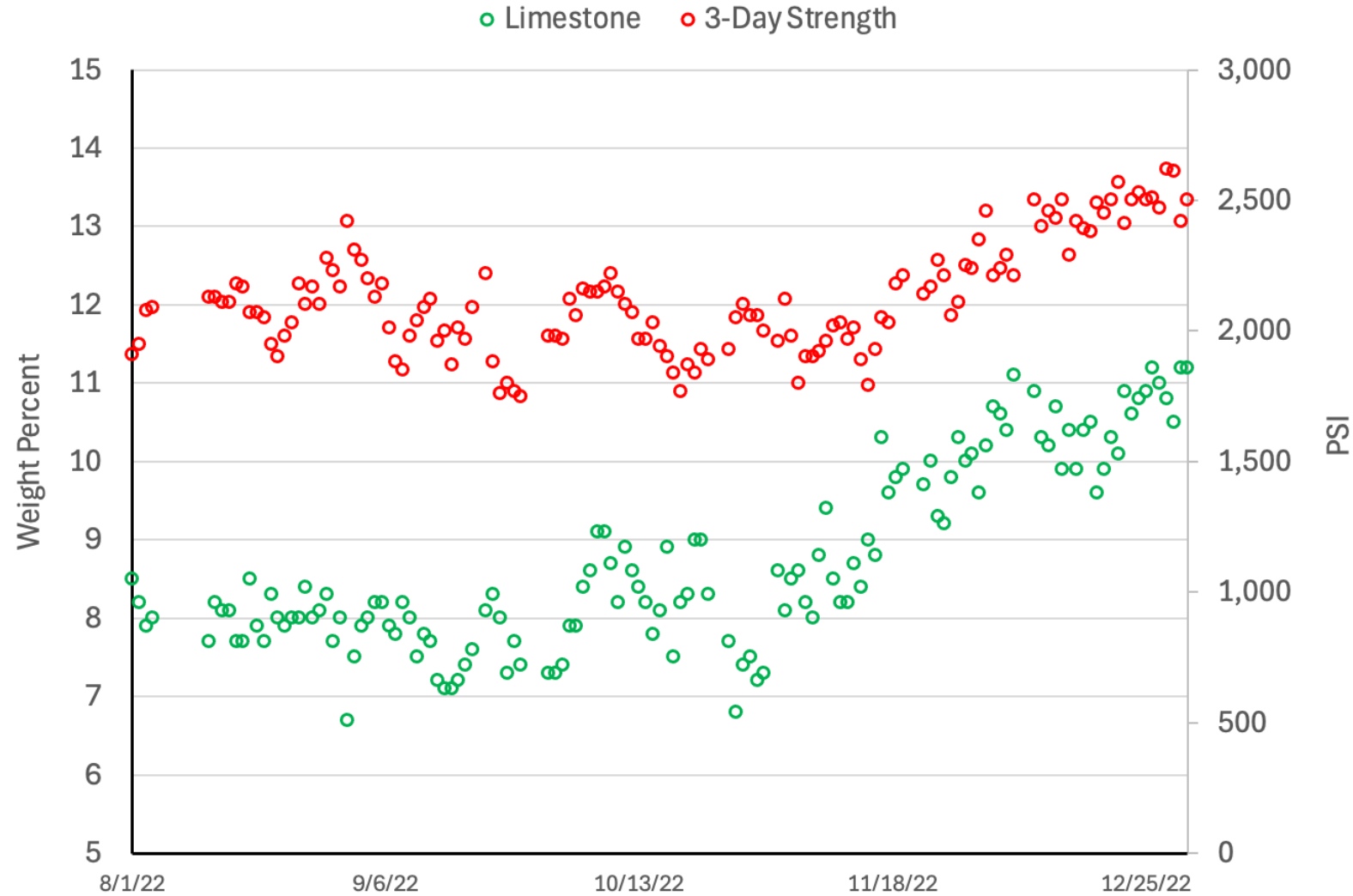


Min (%)	7.3
Max (%)	10.5
Median (%)	9
Average (%)	9.0
Std Dev	0.5
C of V	5.1%
+ 1σ	9.4
- 1σ	8.5
Percent within 2.5%	99.8%
Target	10%

Plant 181 - Limestone & Strength

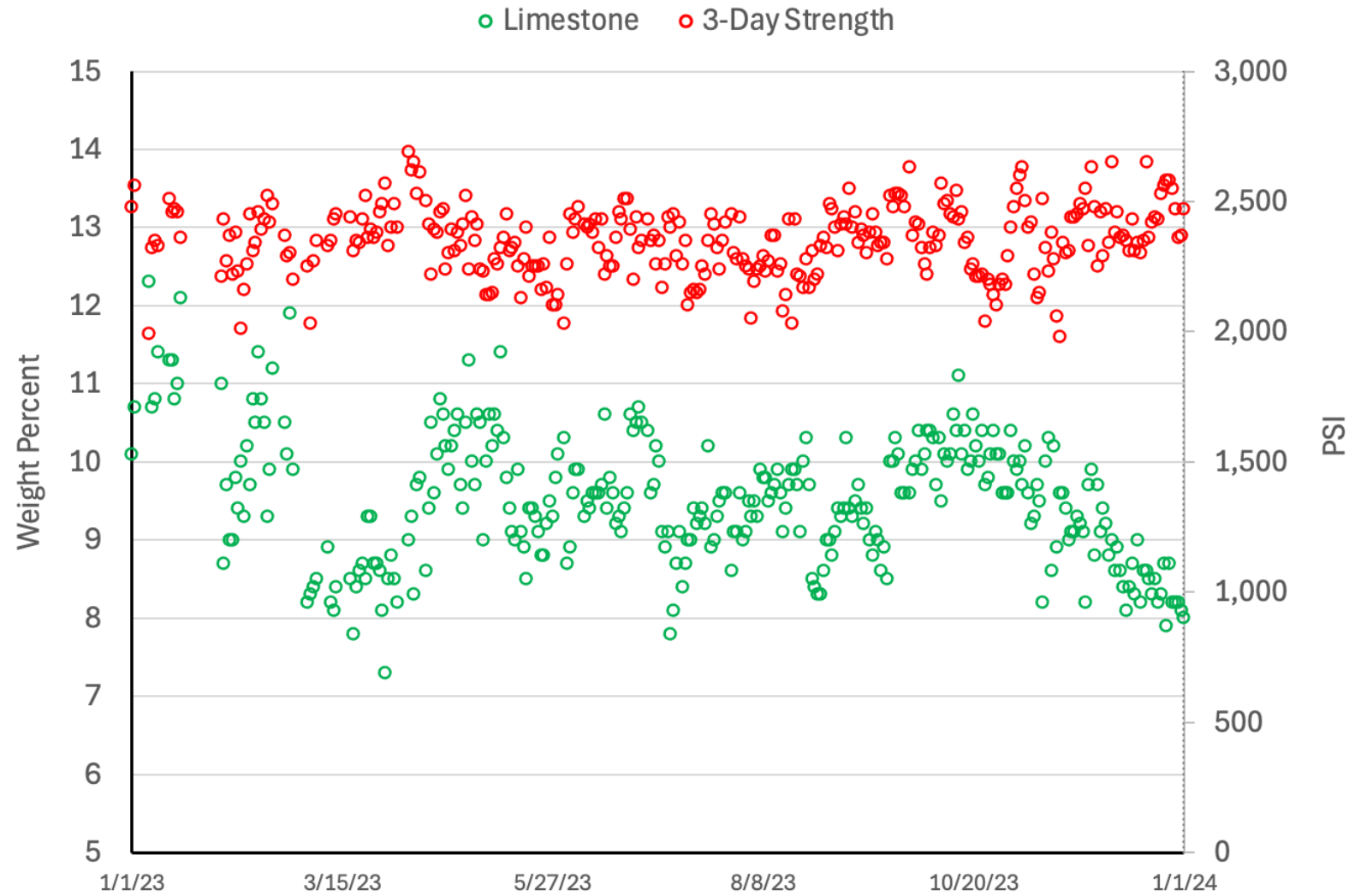


Plant 181 - Limestone & Strength – Year 1



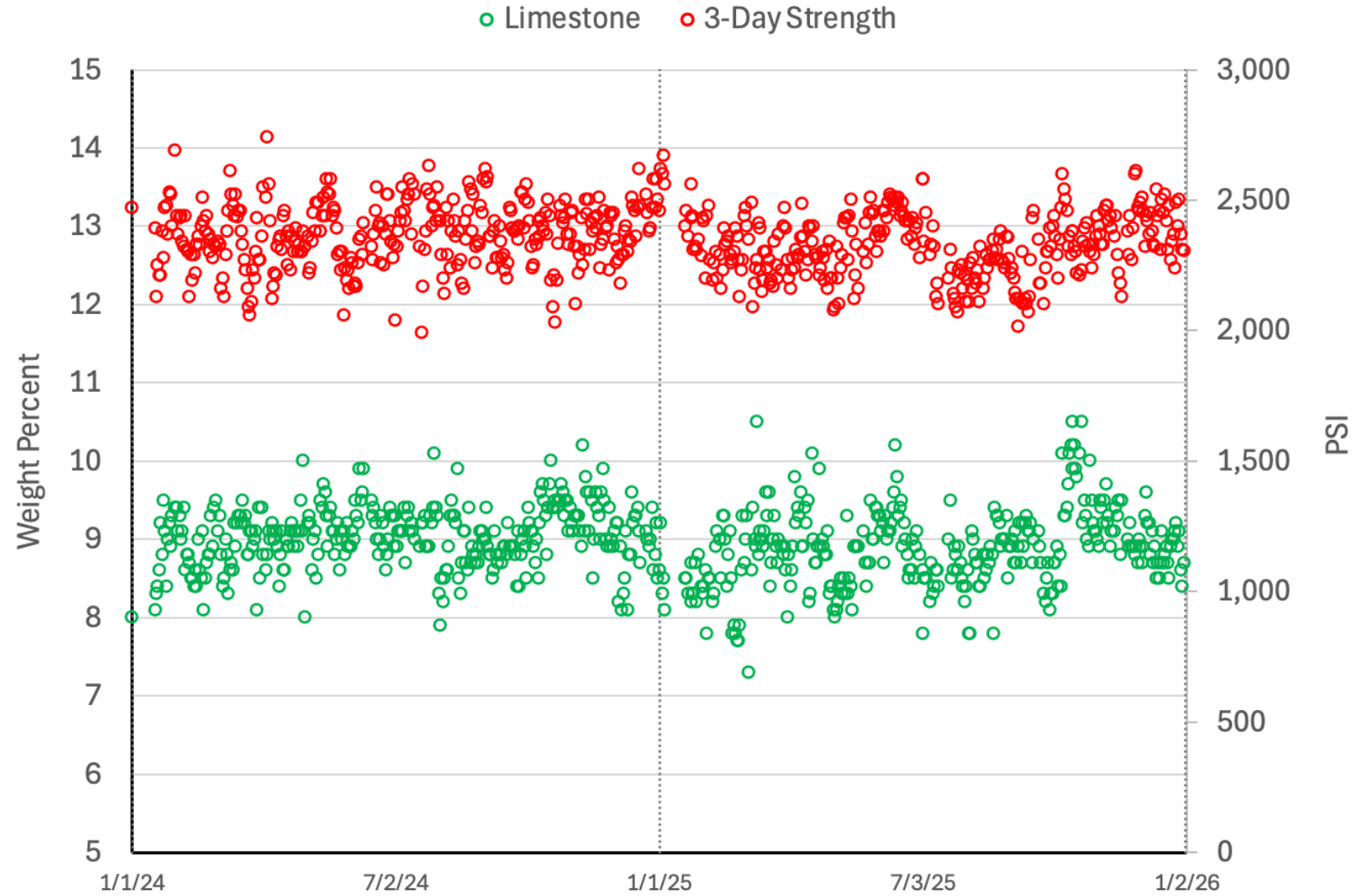
Min (%)	6.7
Max (%)	11.2
Median (%)	8.3
Average (%)	8.7
Std Dev	1.2
C of V	13.5%
+ 1σ	9.9
- 1σ	7.6
Percent within 2.5%	88.9%
Target	10%

Plant 181 - Limestone & Strength – Year 2



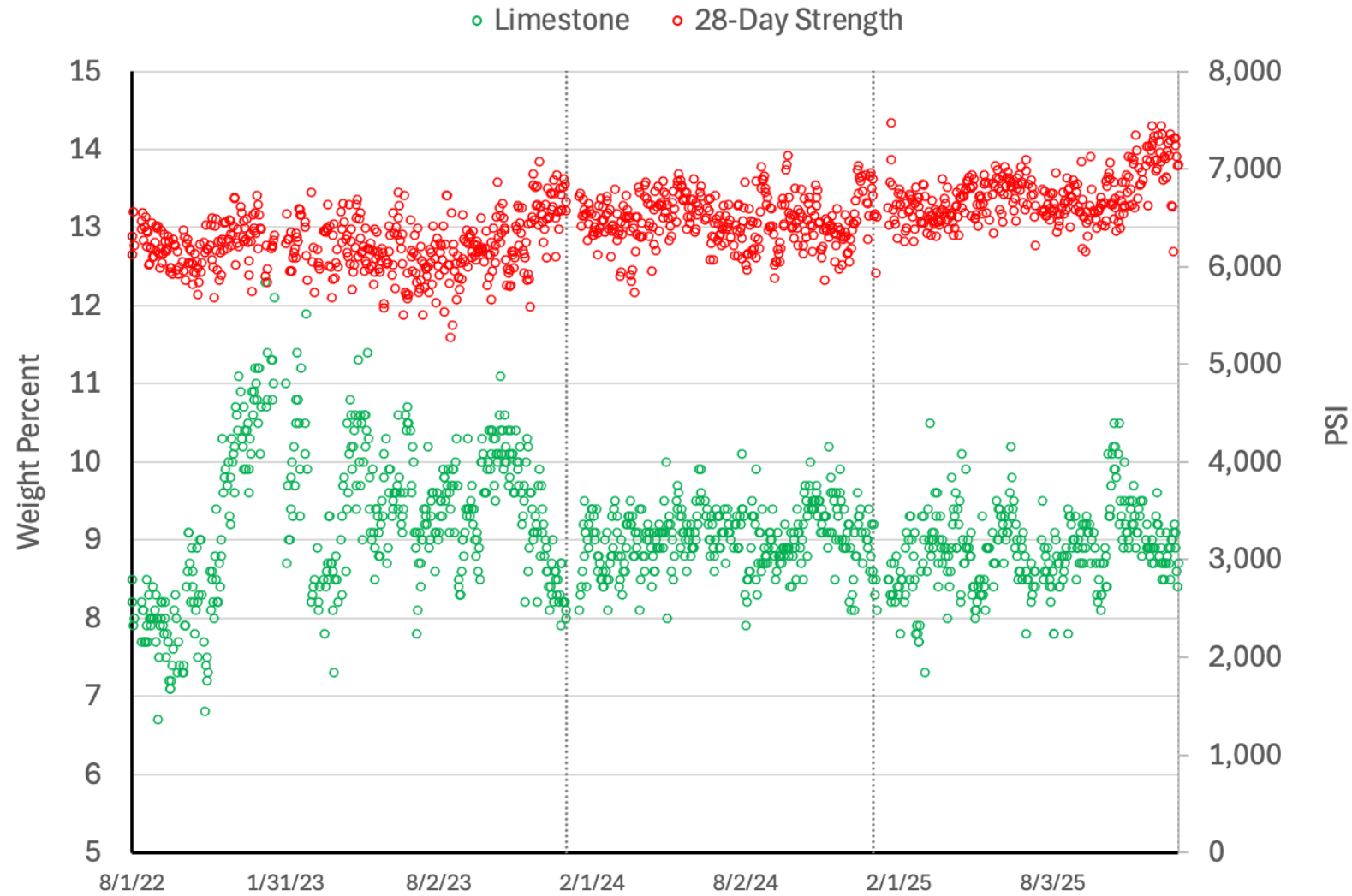
Min (%)	7.3
Max (%)	12.3
Median (%)	9.5
Average (%)	9.5
Std Dev	0.8
C of V	8.6%
+ 1σ	10.3
- 1σ	8.7
Percent within 2.5%	99.7%
Target	10%

Plant 181 - Limestone & Strength – Year 3 & 4



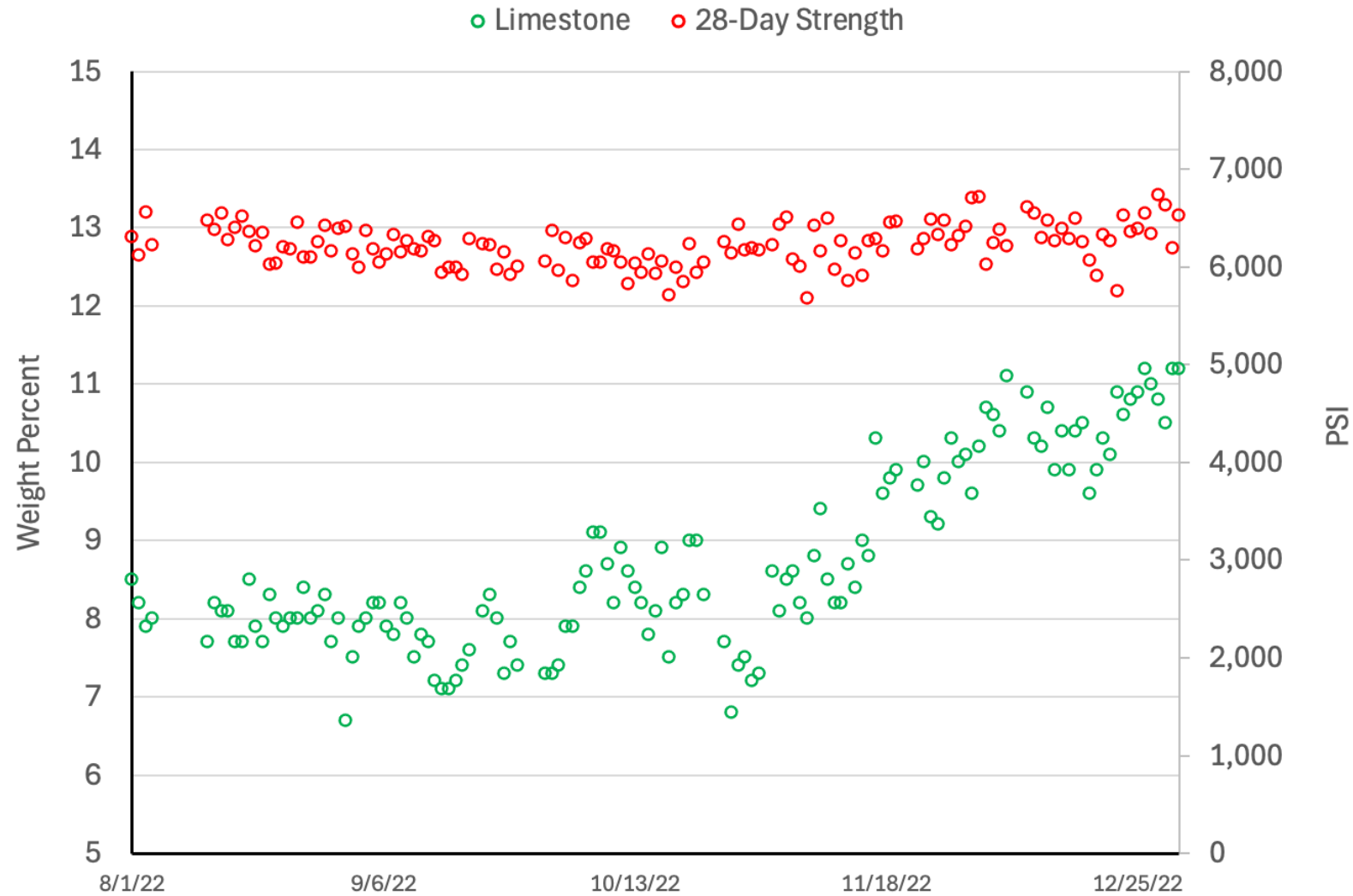
Min (%)	7.3
Max (%)	10.5
Median (%)	9
Average (%)	9.0
Std Dev	0.5
C of V	5.1%
+ 1σ	9.4
- 1σ	8.5
Percent within 2.5%	99.8%
Target	10%

Plant 181 - Limestone & Strength



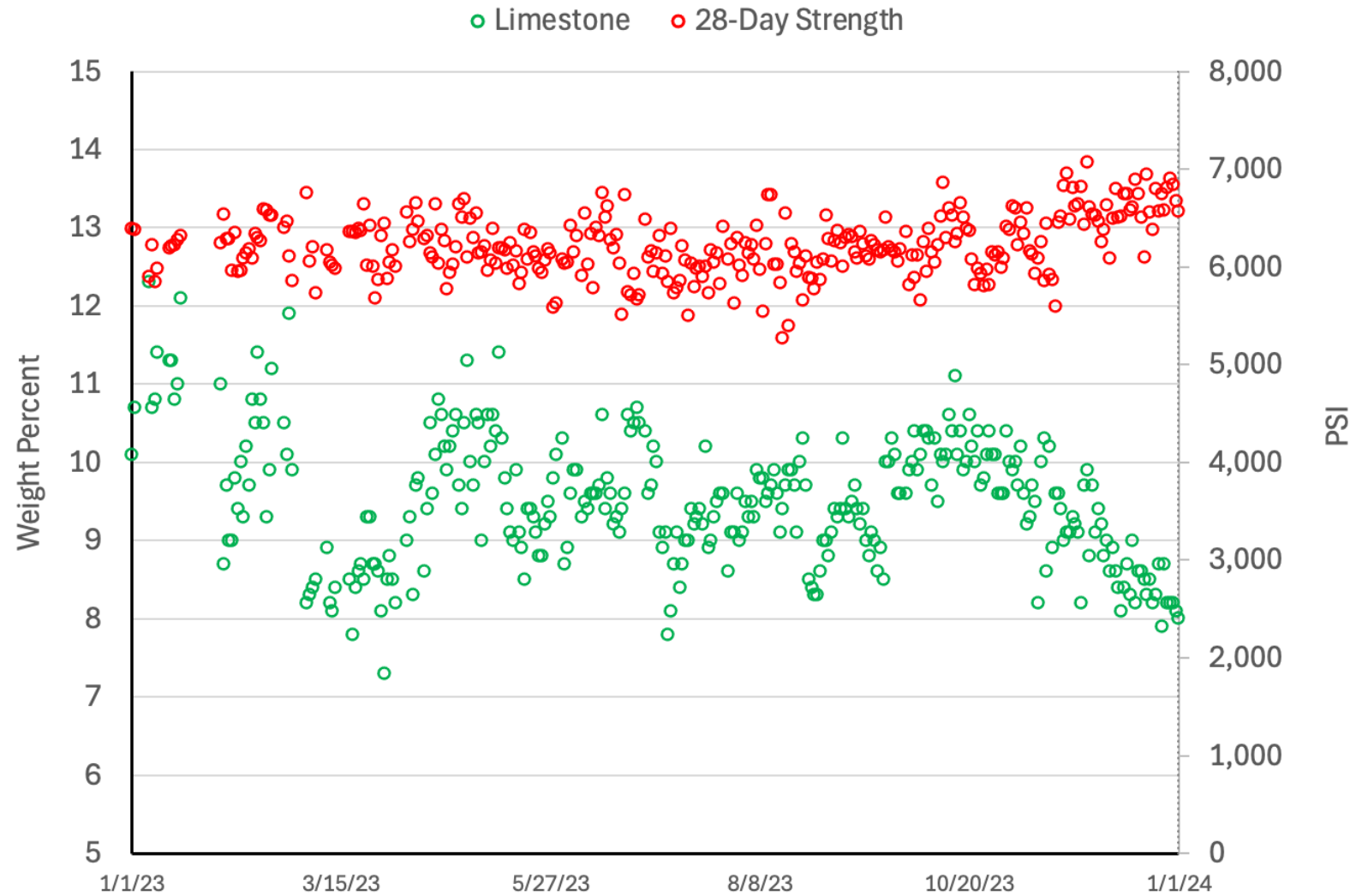
Min (%)	6.7
Max (%)	12.3
Median (%)	9
Average (%)	9.1
Std Dev	0.7
C of V	8.2%
+ 1σ	9.8
- 1σ	8.3
Percent within 2.5%	98.5%
Target	10%

Plant 181 - Limestone & Strength – Year 1



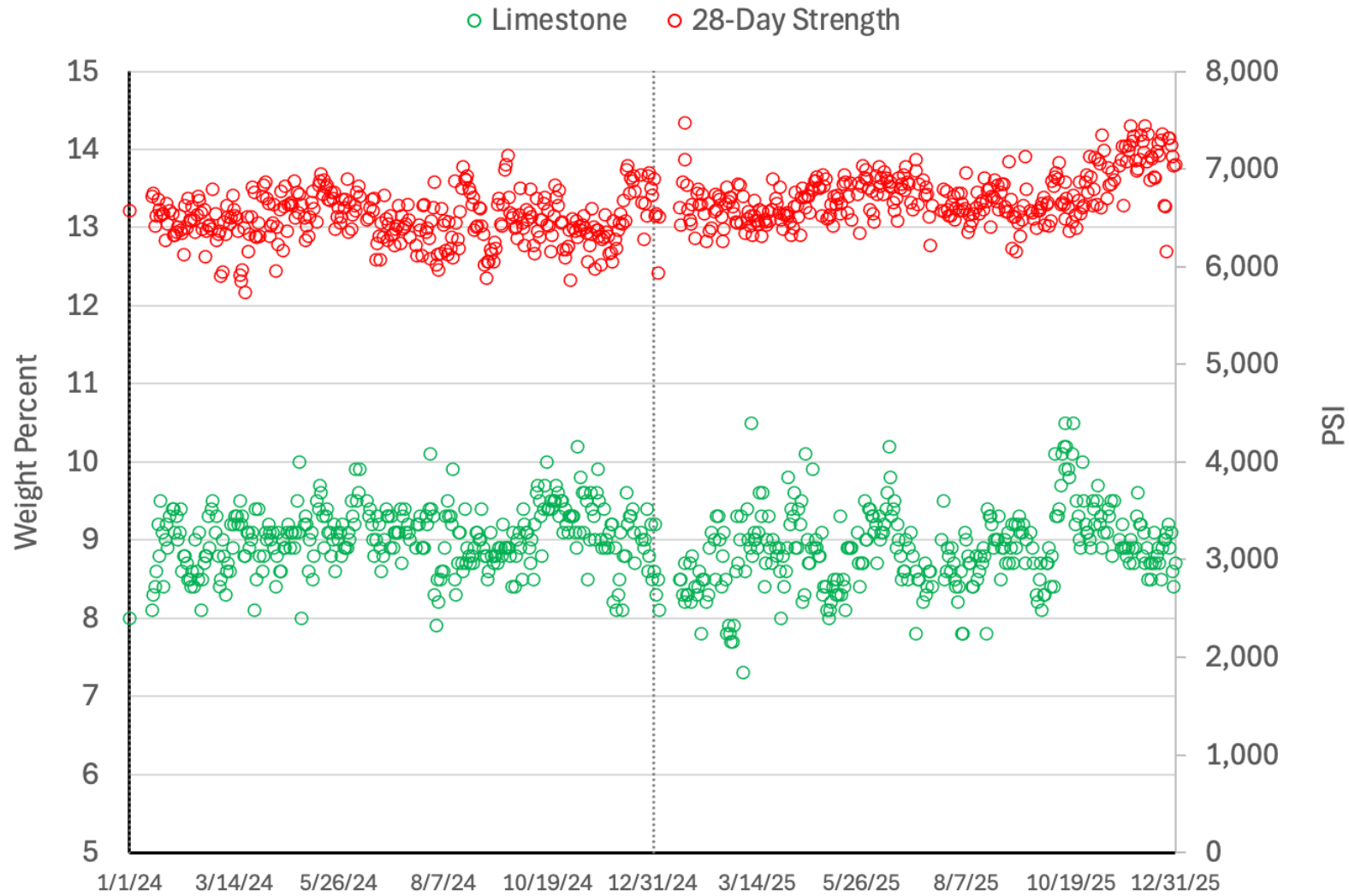
Min (%)	6.7
Max (%)	11.2
Median (%)	8.3
Average (%)	8.7
Std Dev	1.2
C of V	13.5%
+ 1σ	9.9
- 1σ	7.6
Percent within 2.5%	88.9%
Target	10%

Plant 181 - Limestone & Strength – Year 2



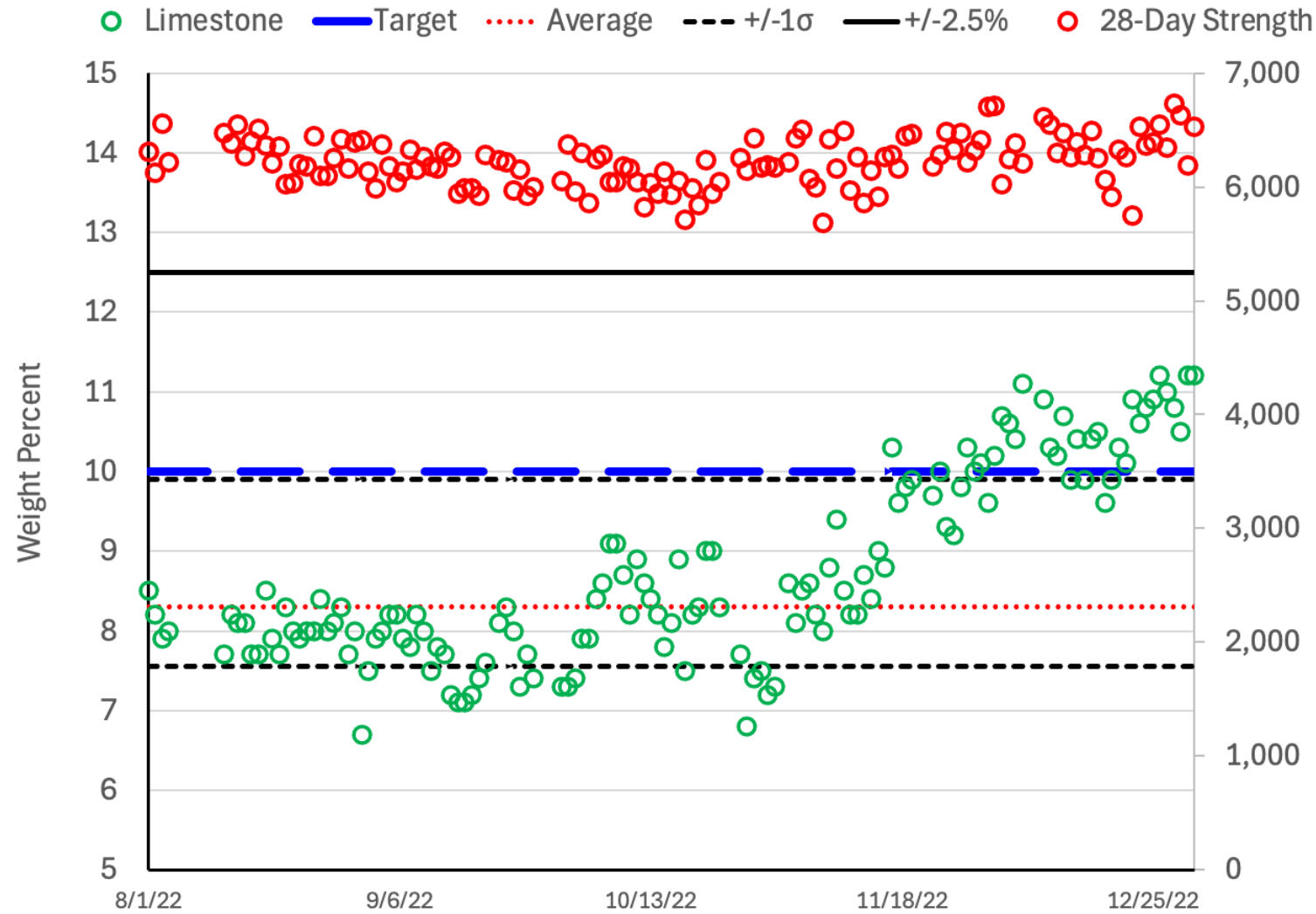
Min (%)	7.3
Max (%)	12.3
Median (%)	9.5
Average (%)	9.5
Std Dev	0.8
C of V	8.6%
+ 1σ	10.3
- 1σ	8.7
Percent within 2.5%	99.7%
Target	10%

Plant 181 - Limestone & Strength – Year 3 & 4

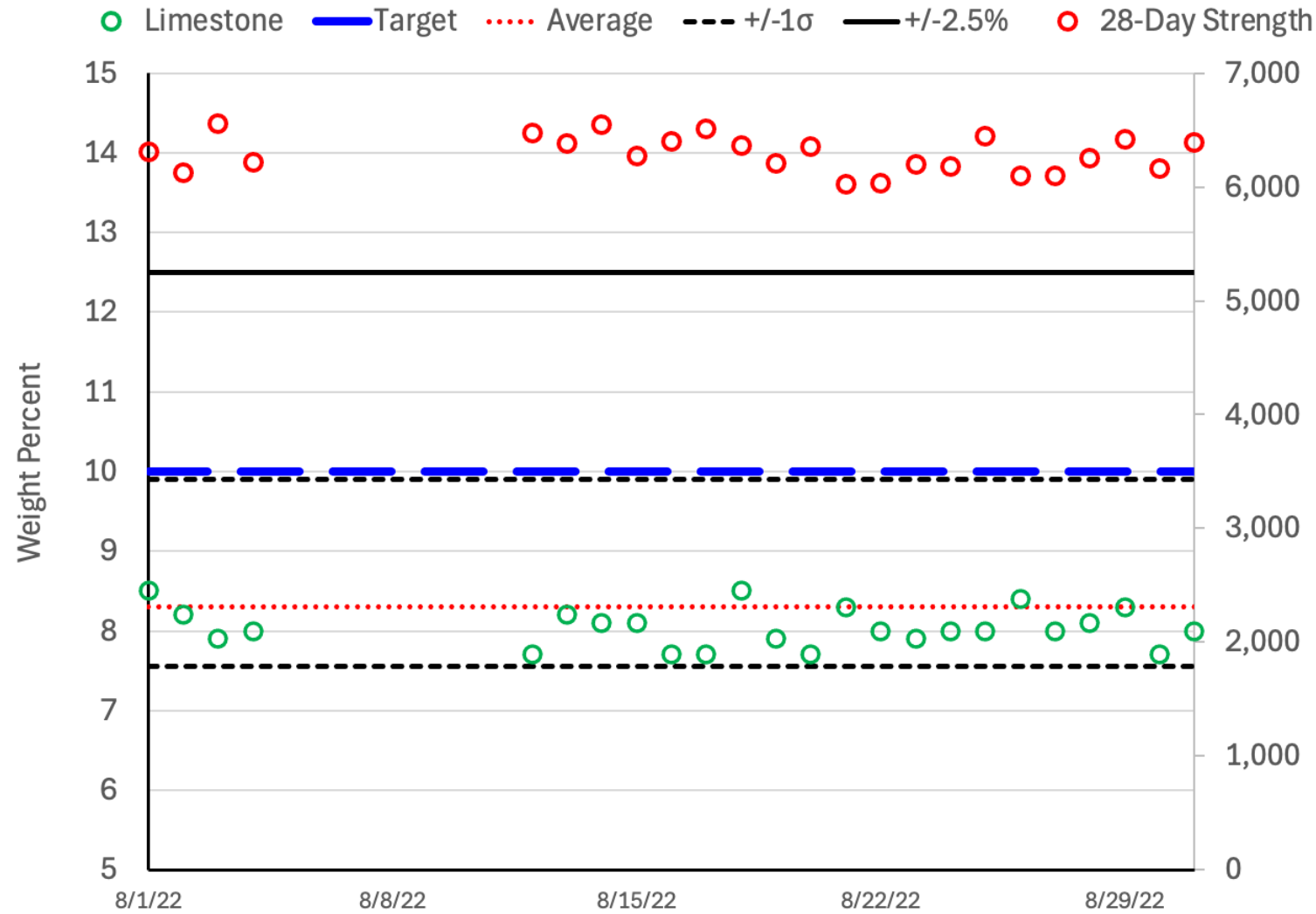


Min (%)	7.3
Max (%)	10.5
Median (%)	9
Average (%)	9.0
Std Dev	0.5
C of V	5.1%
+ 1σ	9.4
- 1σ	8.5
Percent within 2.5%	99.8%
Target	10%

Plant 181 - Limestone & Strength Year 1

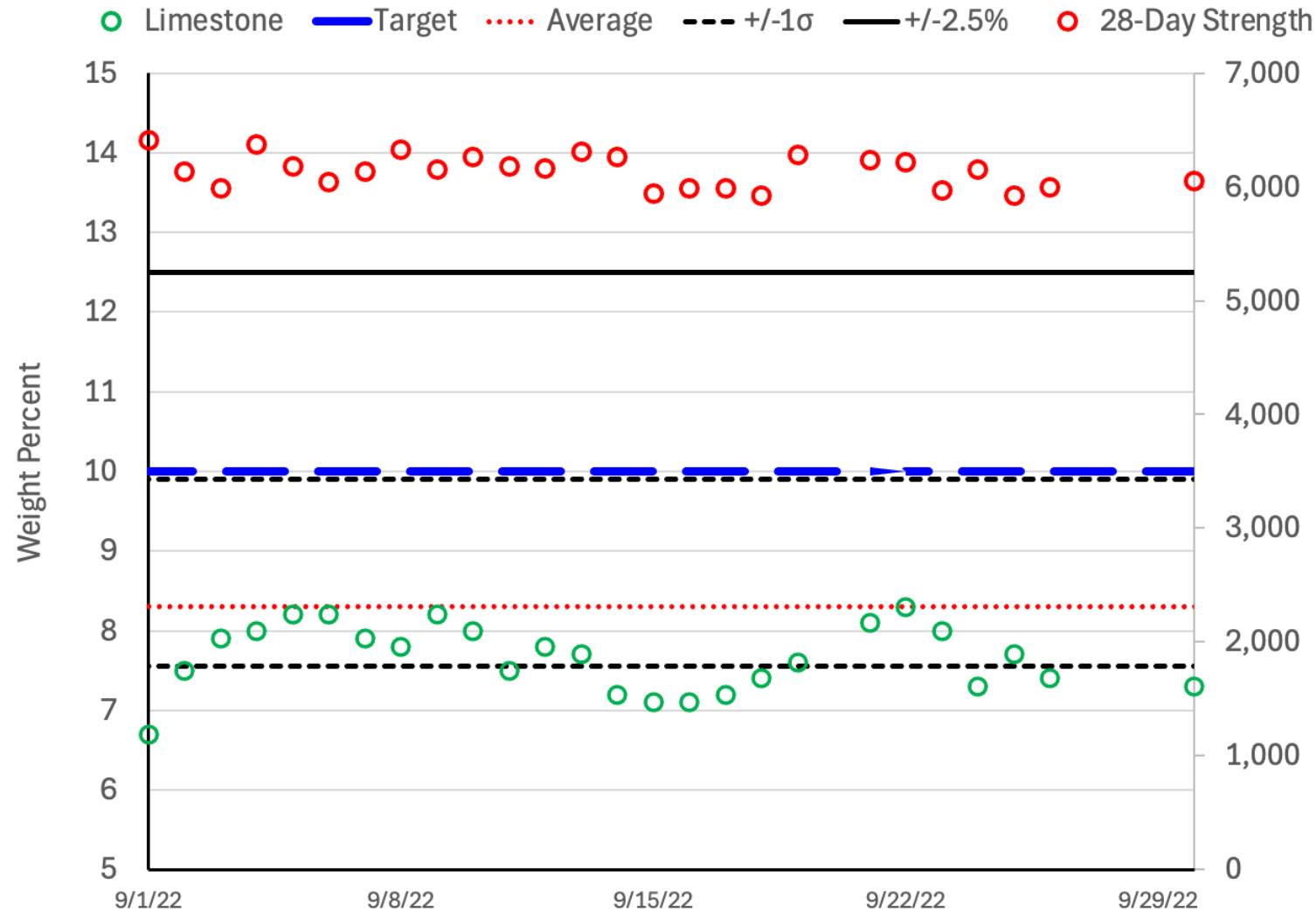


Plant 181 - Limestone & Strength Year 1



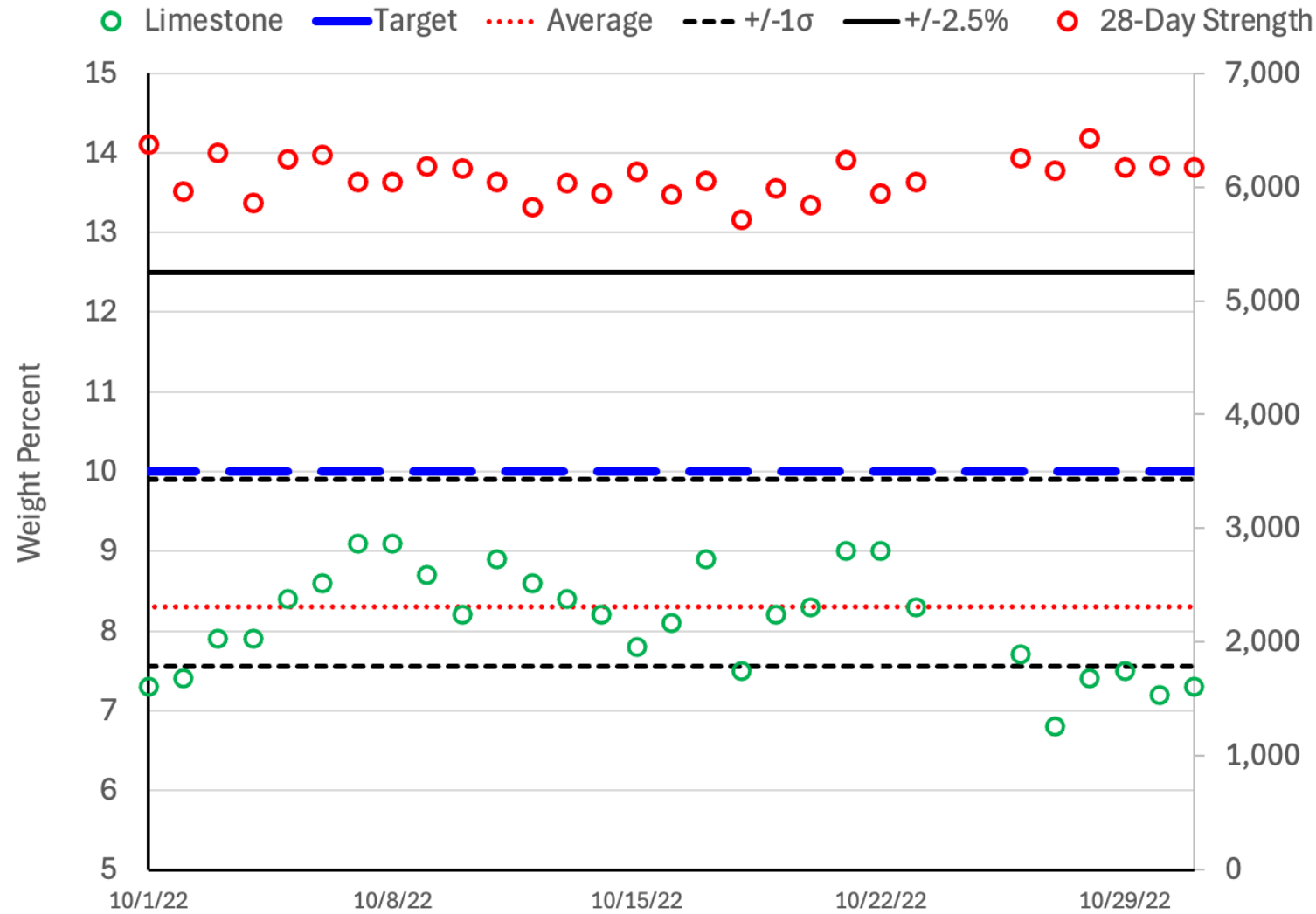
Min (%)	7.7
Max (%)	8.5
Median (%)	8
Average (%)	8.0
Std Dev	0.2
C of V	3.1%
+ 1σ	8.3
- 1σ	7.8
Percent within 2.5%	100.0%
Target	10%

Plant 181 - Limestone & Strength Year 1



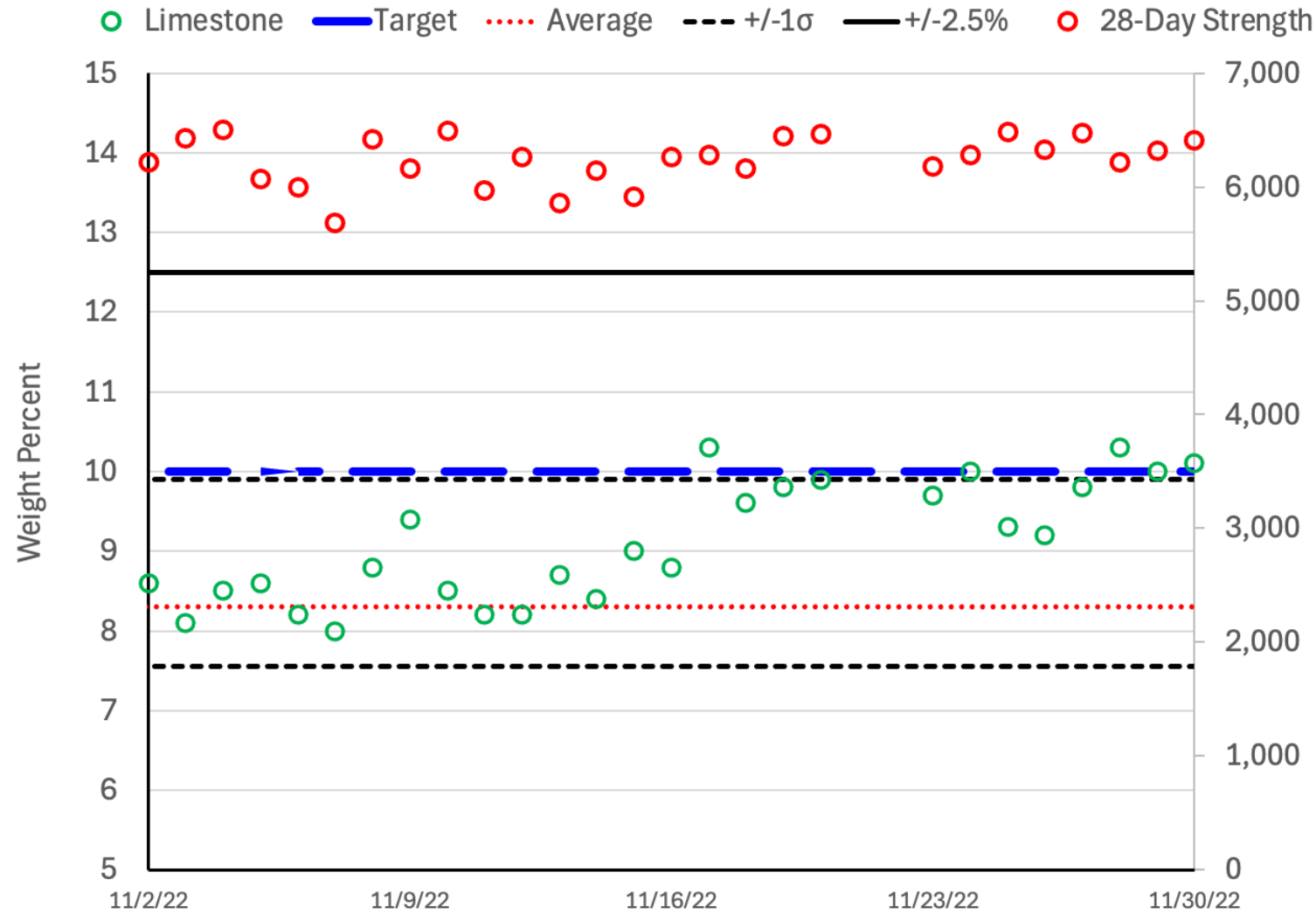
Min (%)	6.7
Max (%)	8.3
Median (%)	7.7
Average (%)	7.7
Std Dev	0.4
C of V	5.5%
+ 1σ	8.1
- 1σ	7.2
Percent within 2.5%	65.4%
Target	10%

Plant 181 - Limestone & Strength Year 1



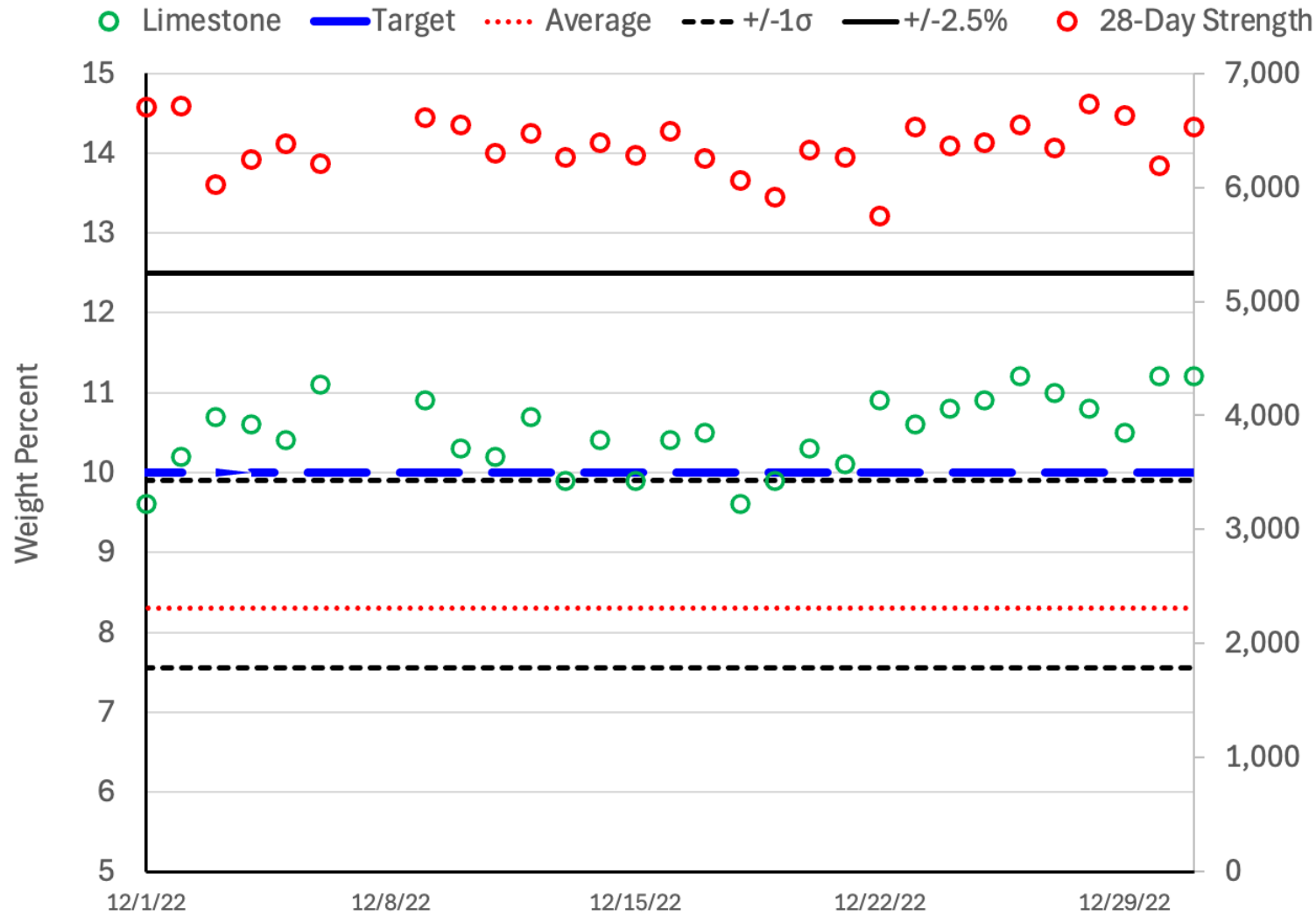
Min (%)	6.8
Max (%)	9.1
Median (%)	8.2
Average (%)	8.1
Std Dev	0.7
C of V	8.0%
+ 1σ	8.8
- 1σ	7.5
Percent within 2.5%	79.3%
Target	10%

Plant 181 - Limestone & Strength Year 1



Min (%)	8
Max (%)	10.3
Median (%)	9
Average (%)	9.1
Std Dev	0.7
C of V	8.2%
+ 1σ	9.9
- 1σ	8.4
Percent within 2.5%	100.0%
Target	10%

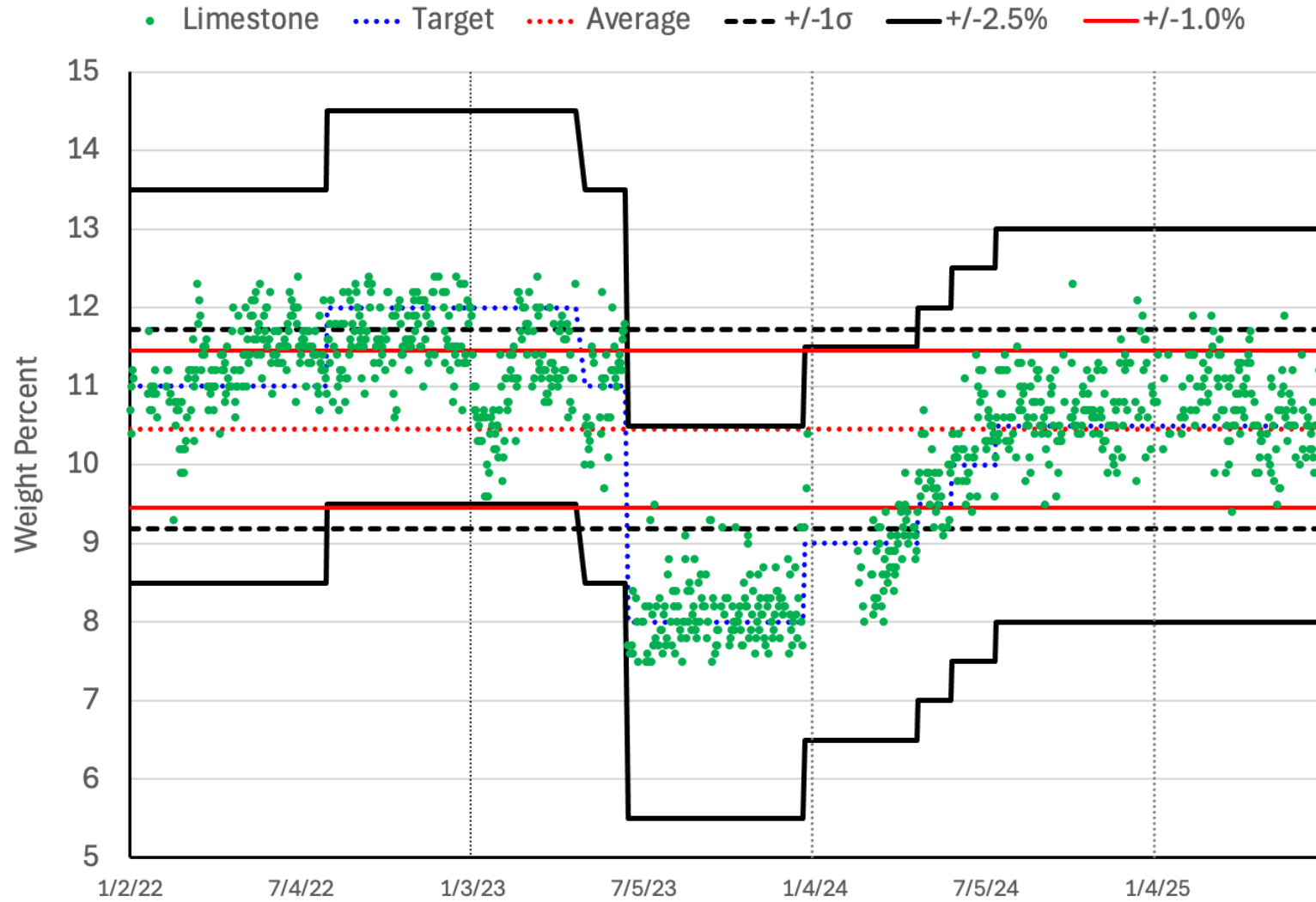
Plant 181 - Limestone & Strength Year 1



Min (%)	9.6
Max (%)	11.2
Median (%)	10.5
Average (%)	10.5
Std Dev	0.5
C of V	4.4%
+ 1σ	11.0
- 1σ	10.0
Percent within 2.5%	100.0%
Target	10%

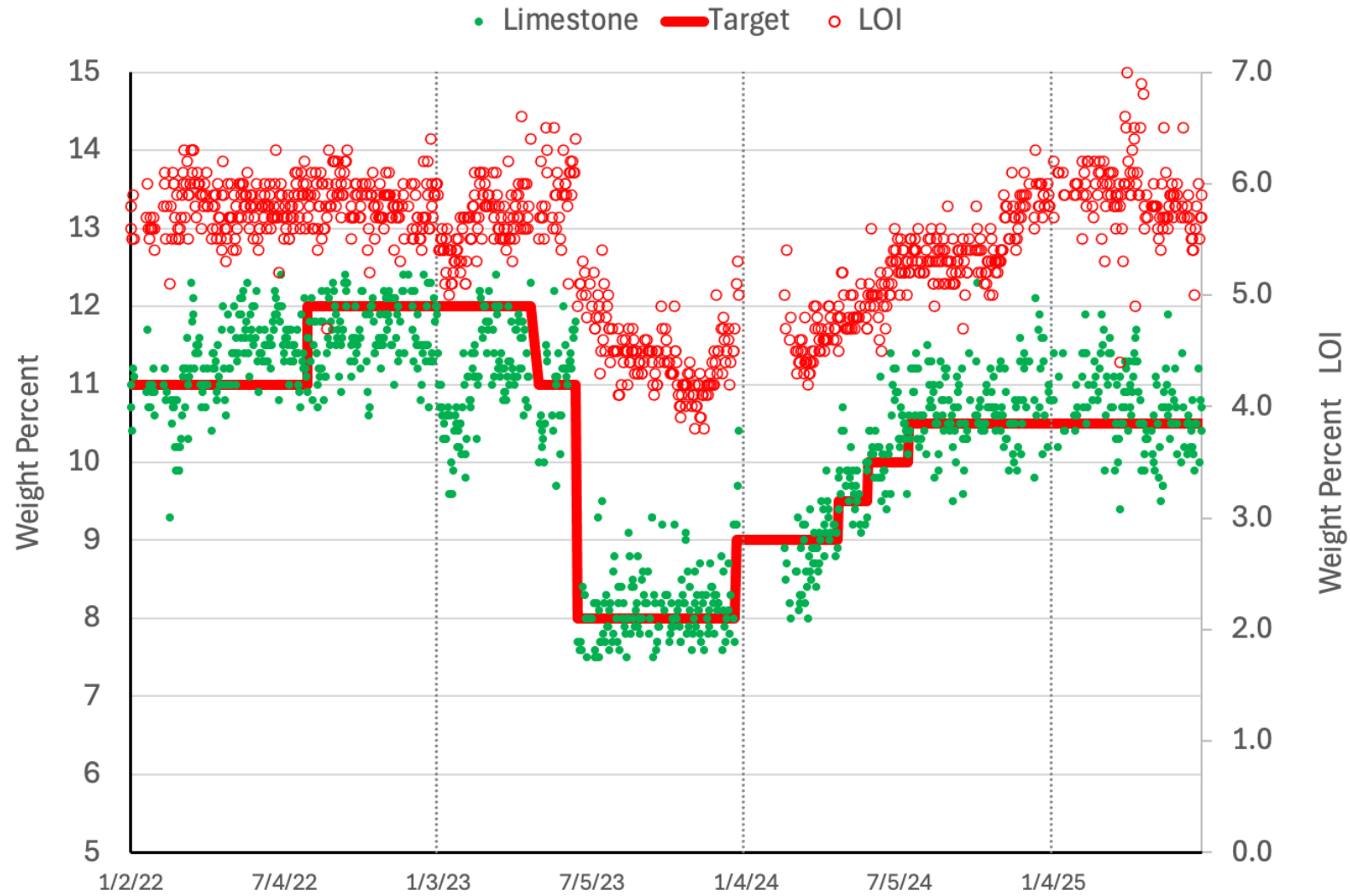


Plant 494 - Limestone

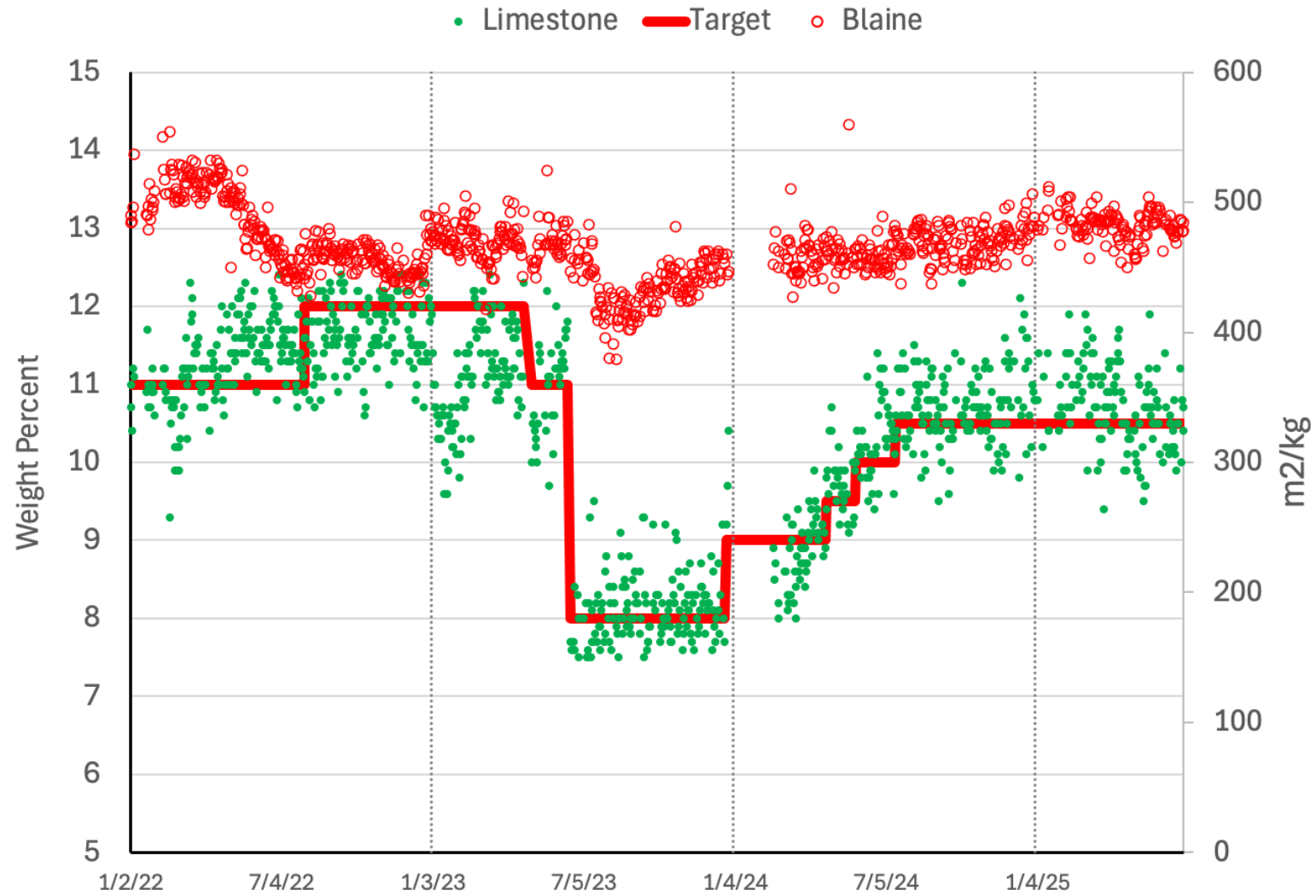


Min (%)	7.5
Max (%)	12.4
Median (%)	10.8
Average (%)	10.5
Std Dev	1.3
C of V	12.1%
+ 1σ	11.7
- 1σ	9.2
Percent within 2.5%	100.0%

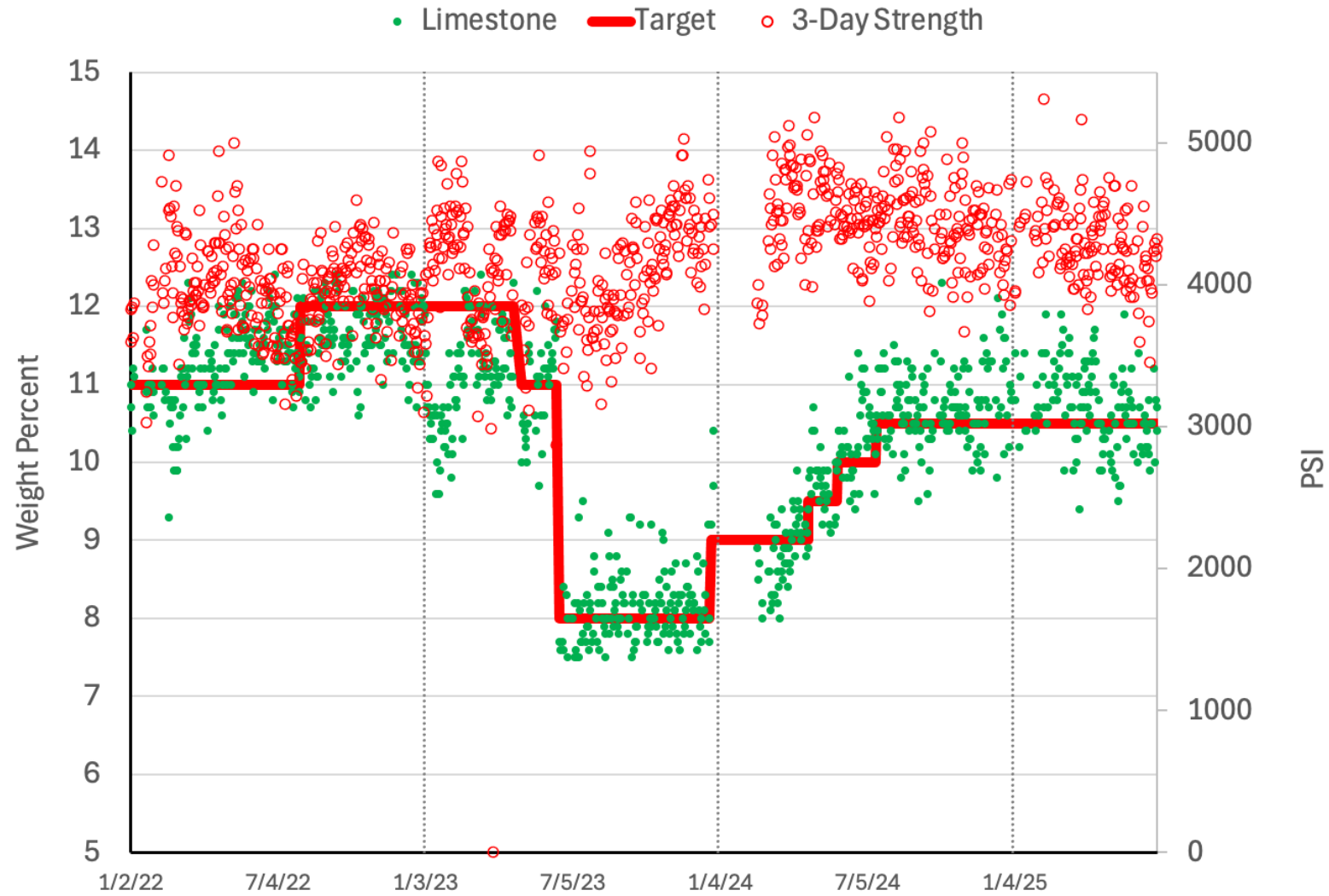
Plant 494 - Limestone & LOI



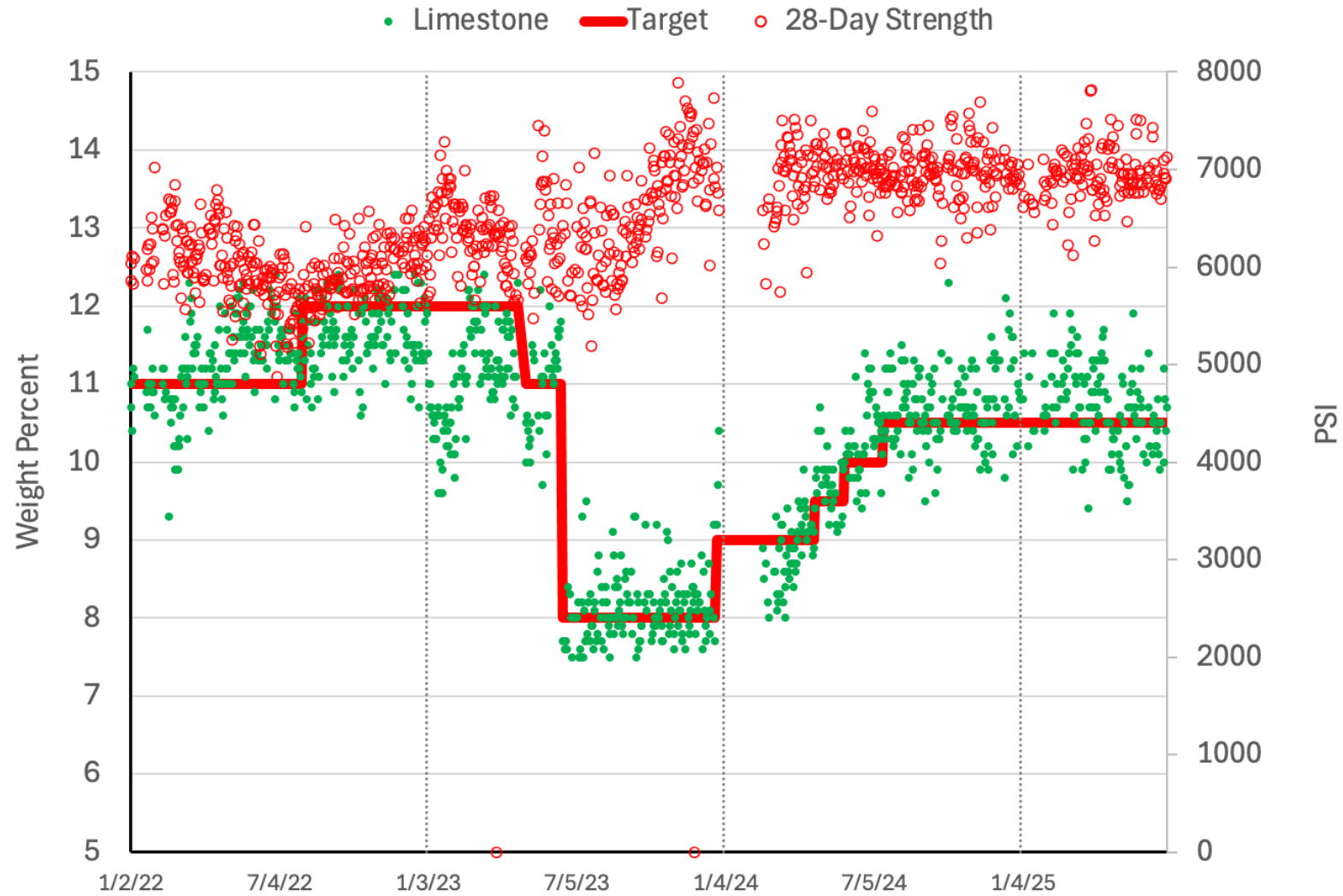
Plant 494 - Limestone & Blaine



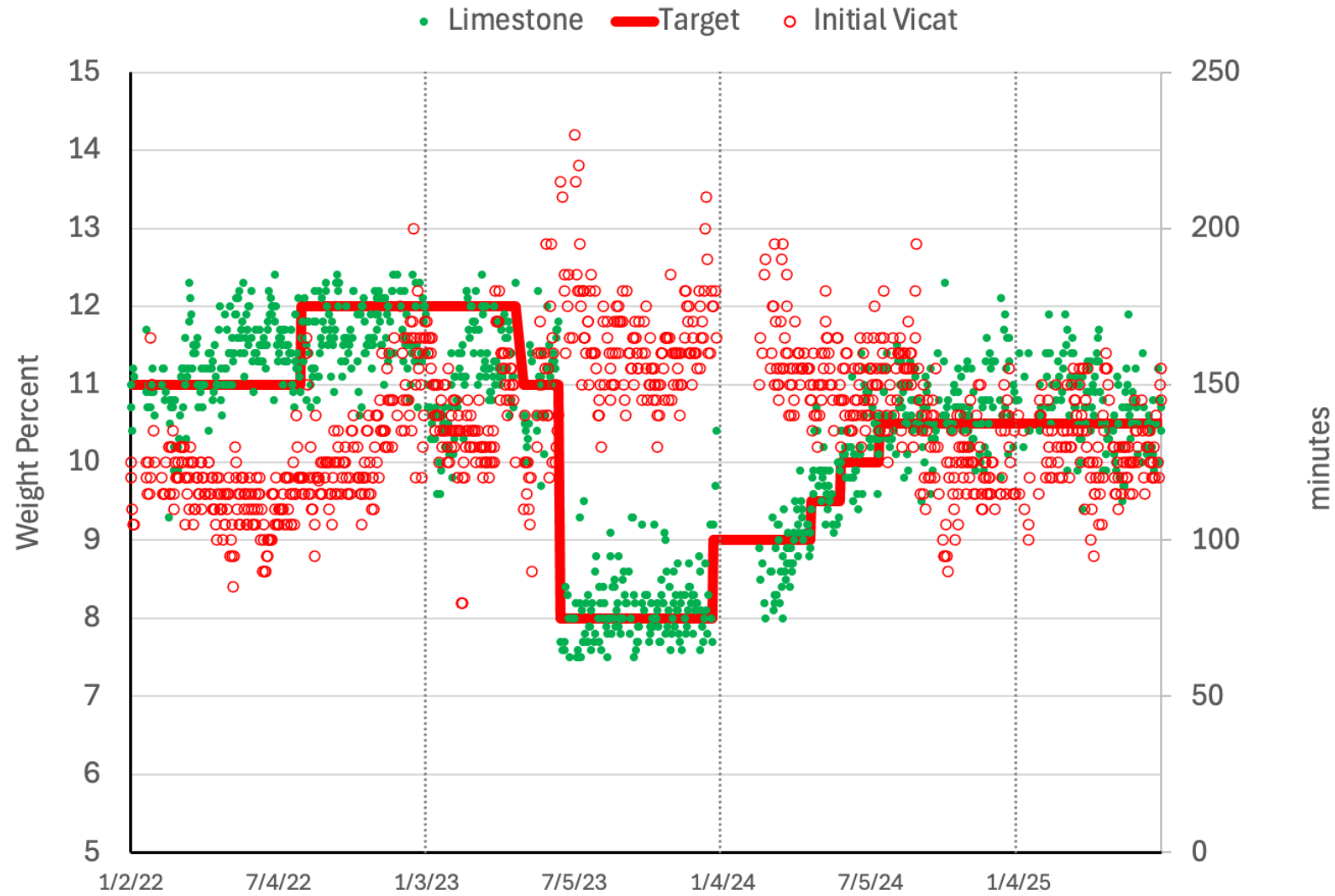
Plant 494 - Limestone & Strength



Plant 494 - Limestone & Strength



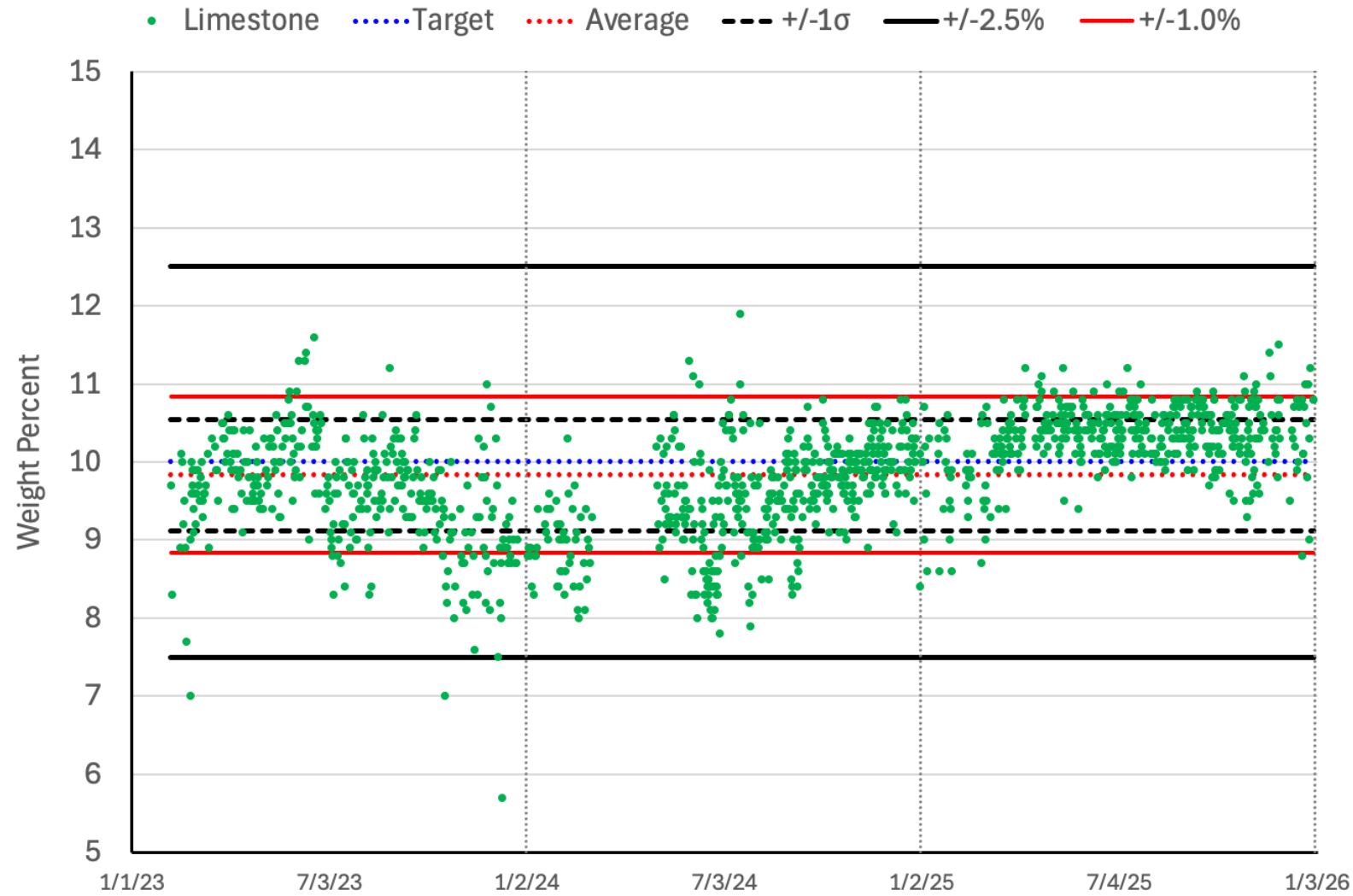
Plant 494 - Limestone & Vicat



**I
think
cement
is more
interesting
than people think.**

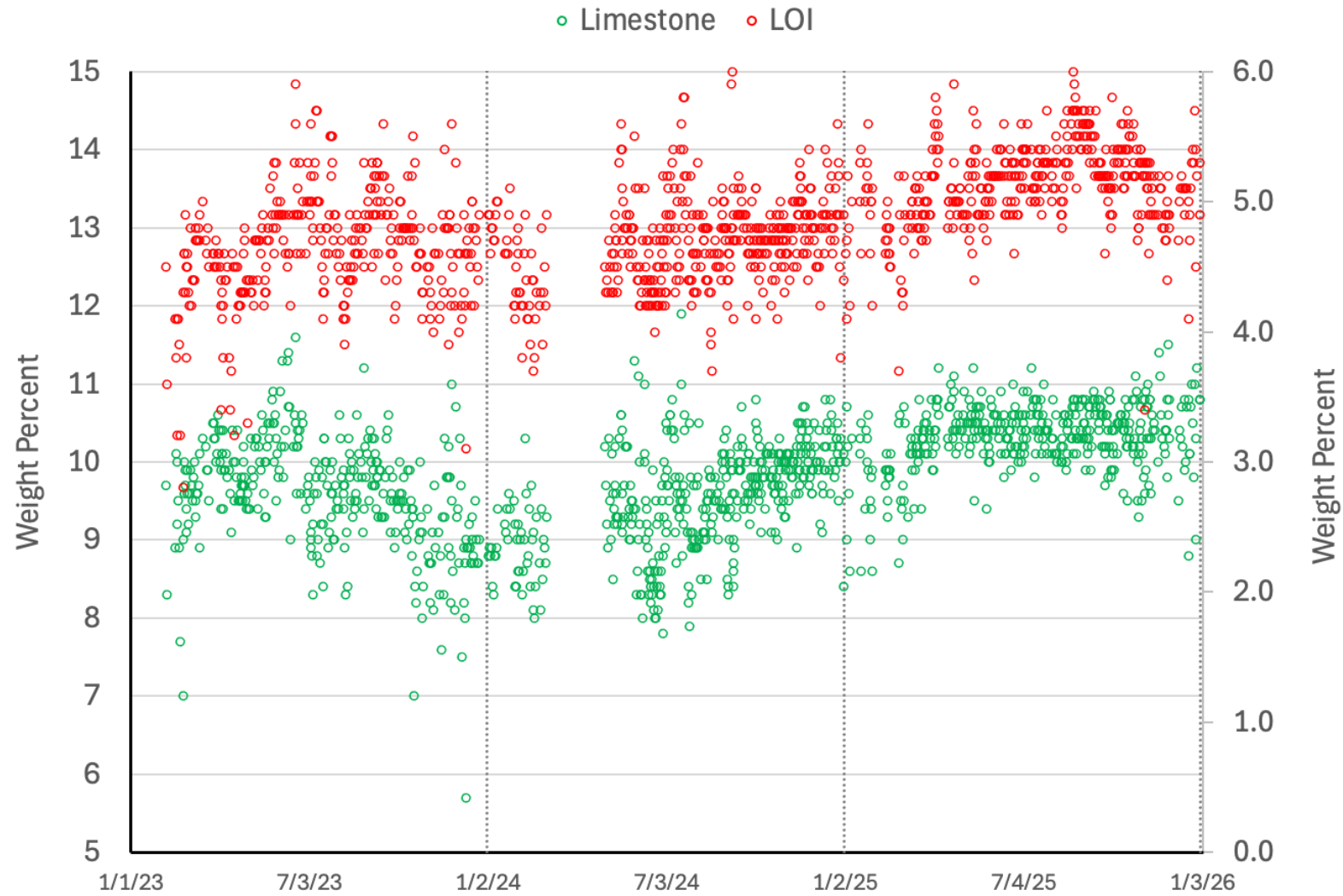


Plant 342 - Limestone

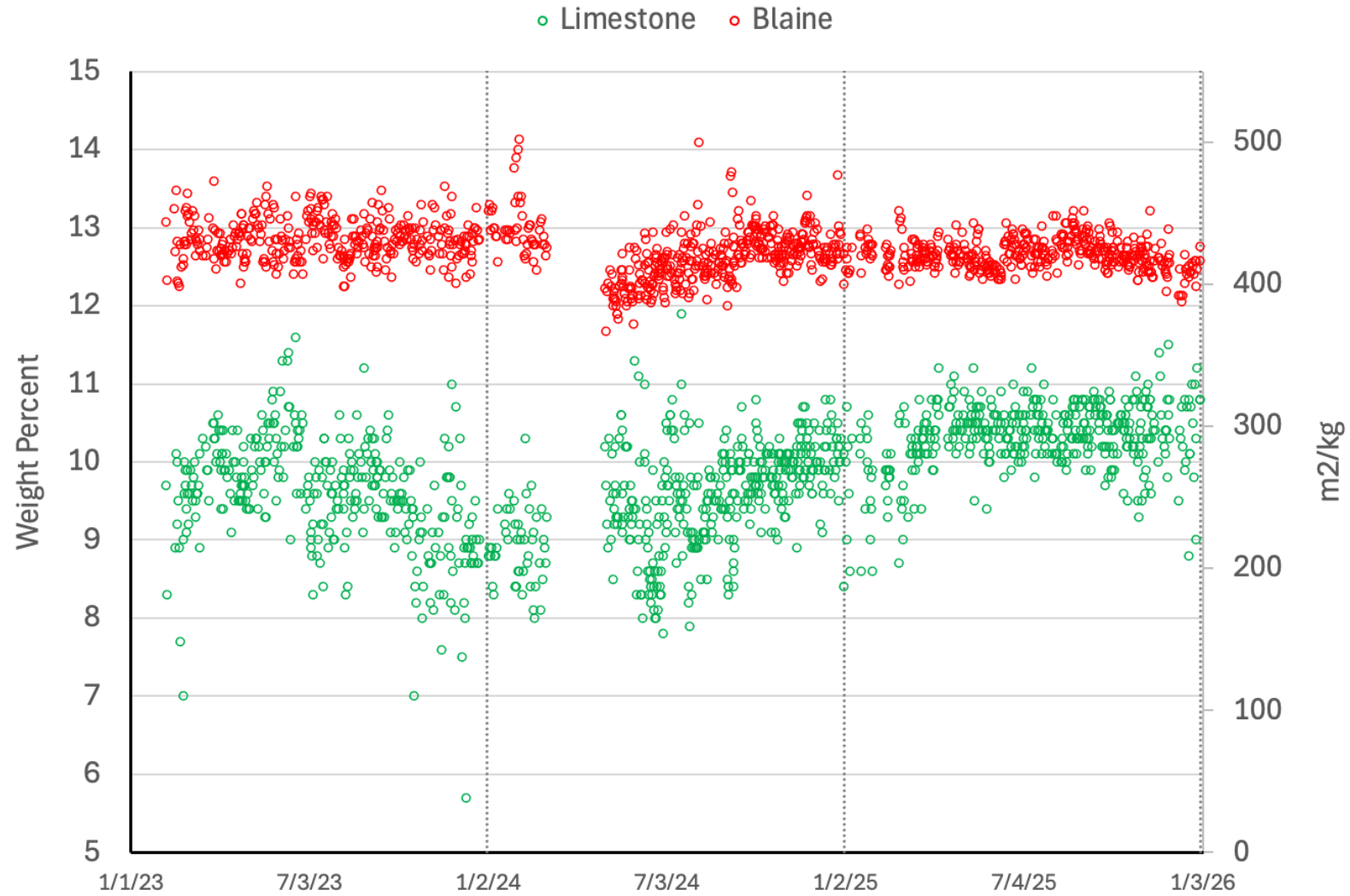


Min (%)	5.7
Max (%)	11.9
Median (%)	9.9
Average (%)	9.8
Std Dev	0.7
C of V	7.3%
+ 1 σ	10.5
- 1 σ	9.1
Percent within 2.5%	99.7%
Target	10%

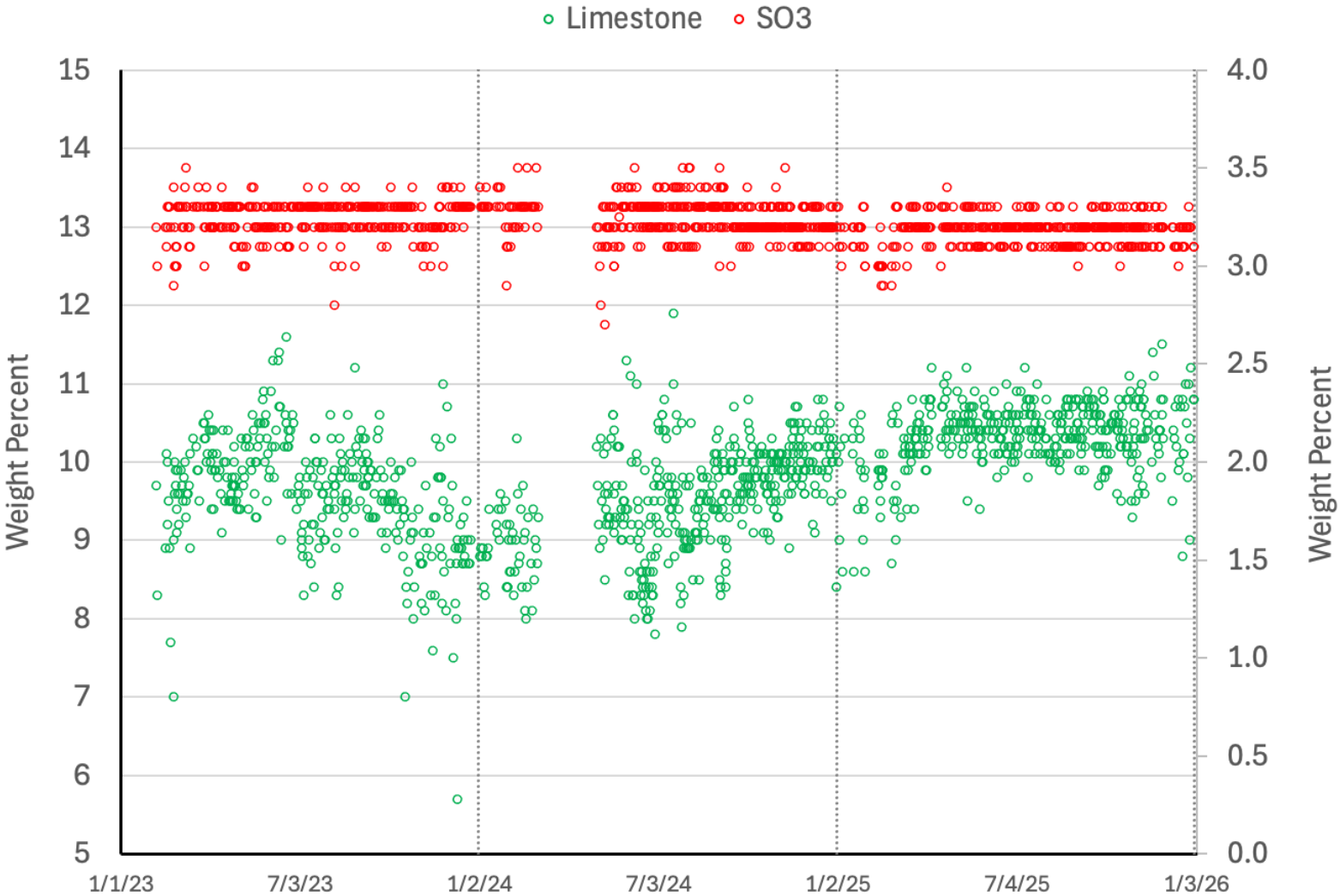
Plant 342 - Limestone & LOI



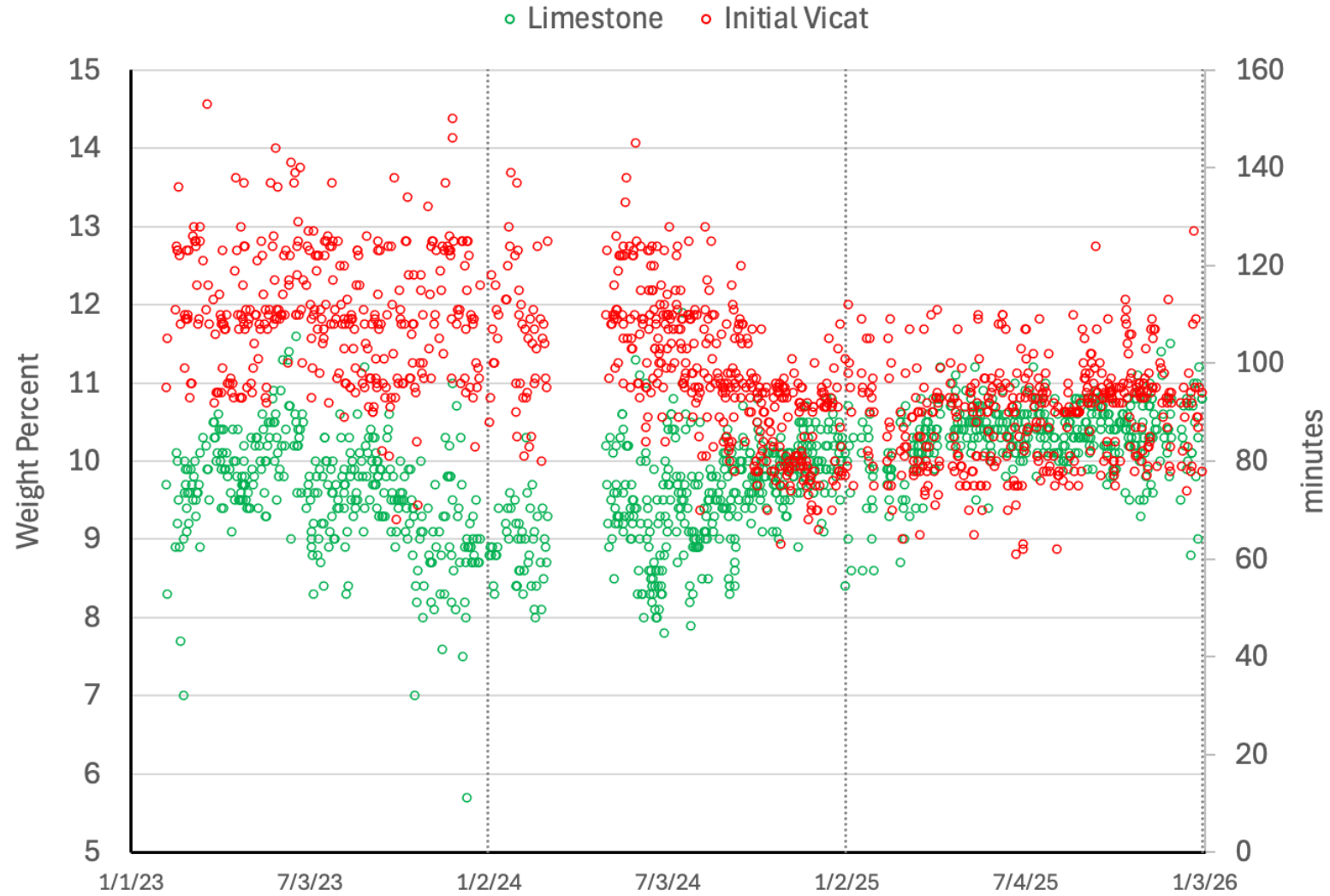
Plant 342 - Limestone & Blaine



Plant 342 - Limestone & SO3



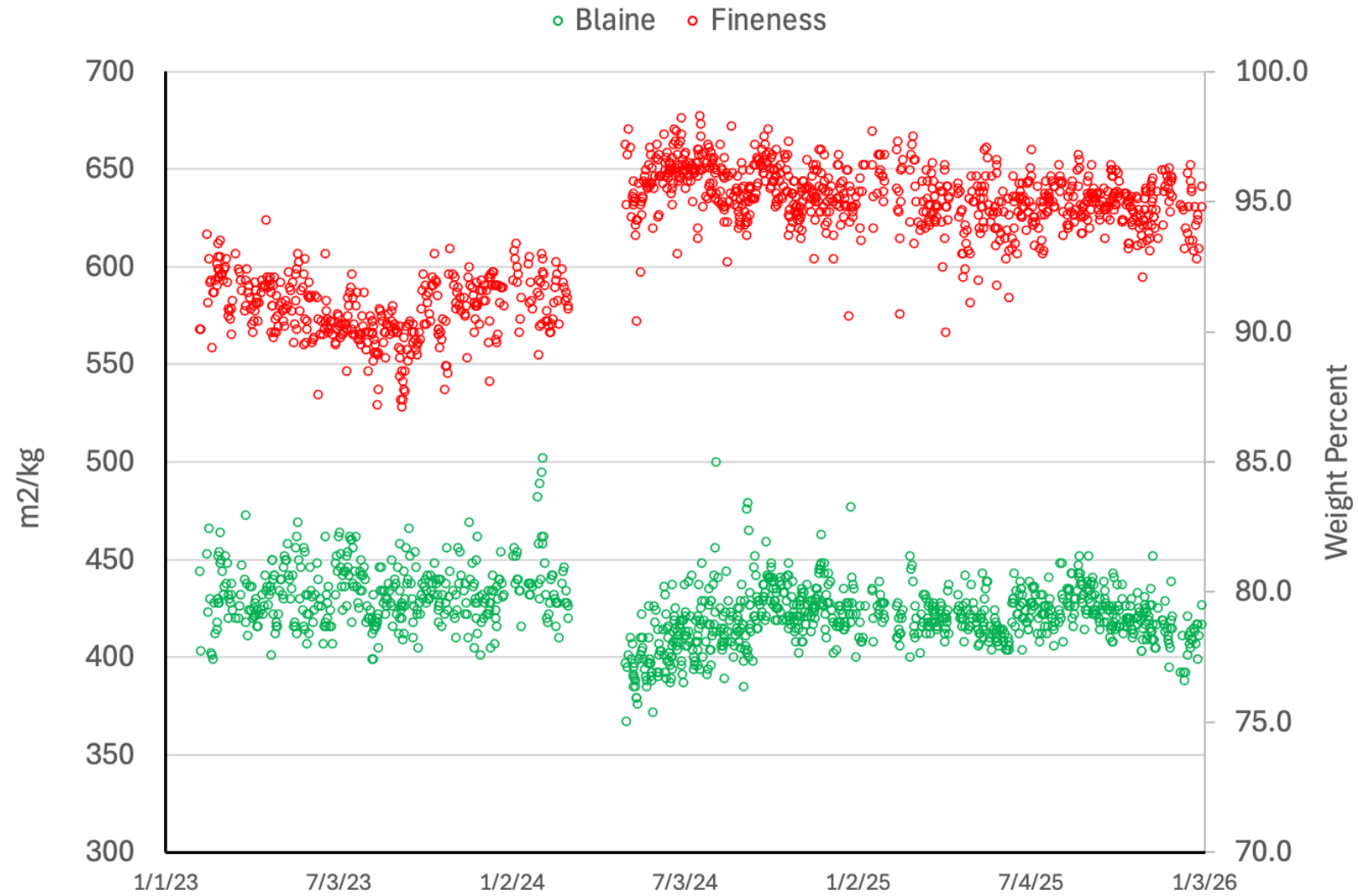
Plant 342 - Limestone & Vicat



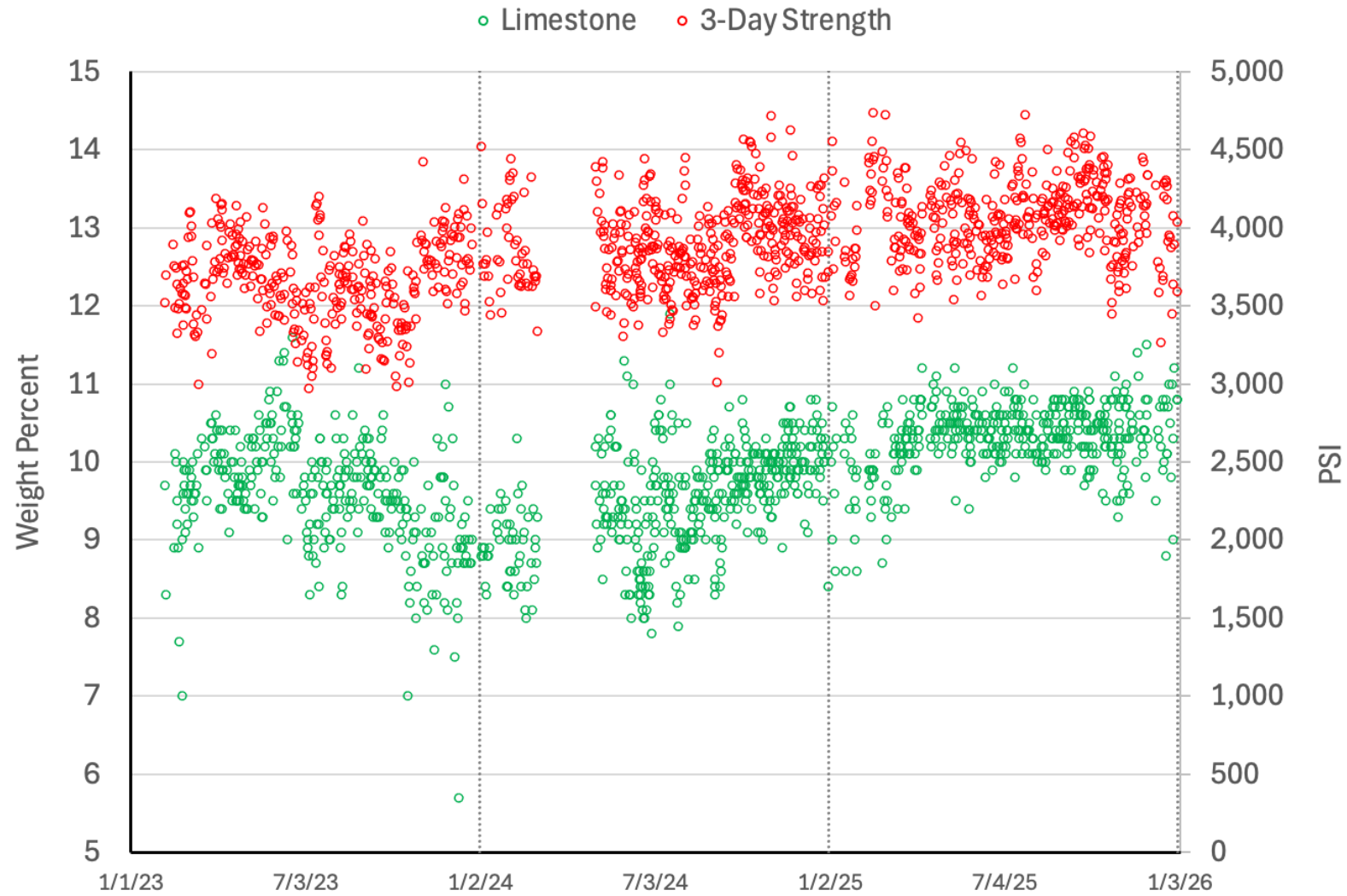
Plant 342 - Limestone & Fineness



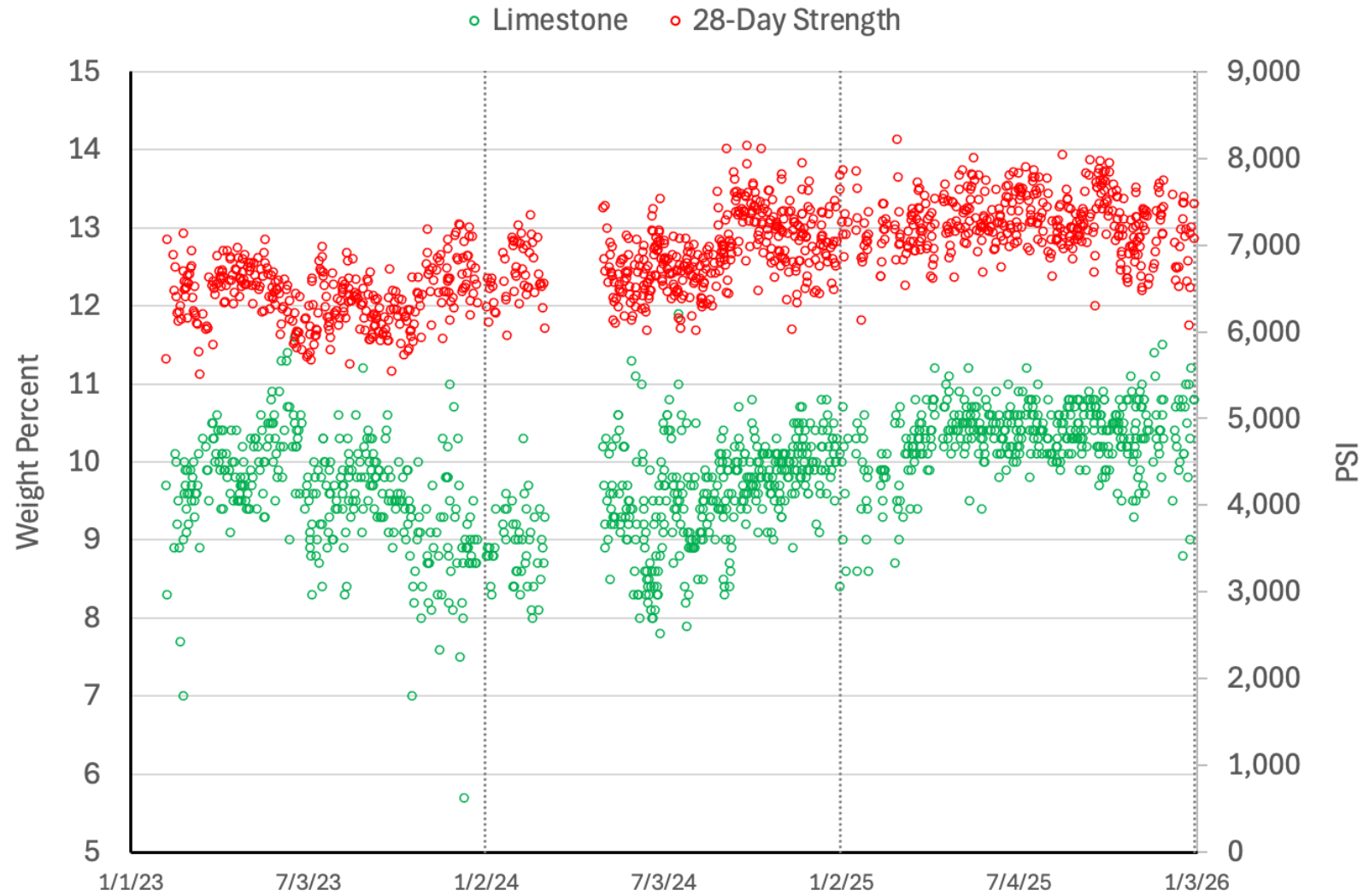
Plant 342 - Fineness & Blaine



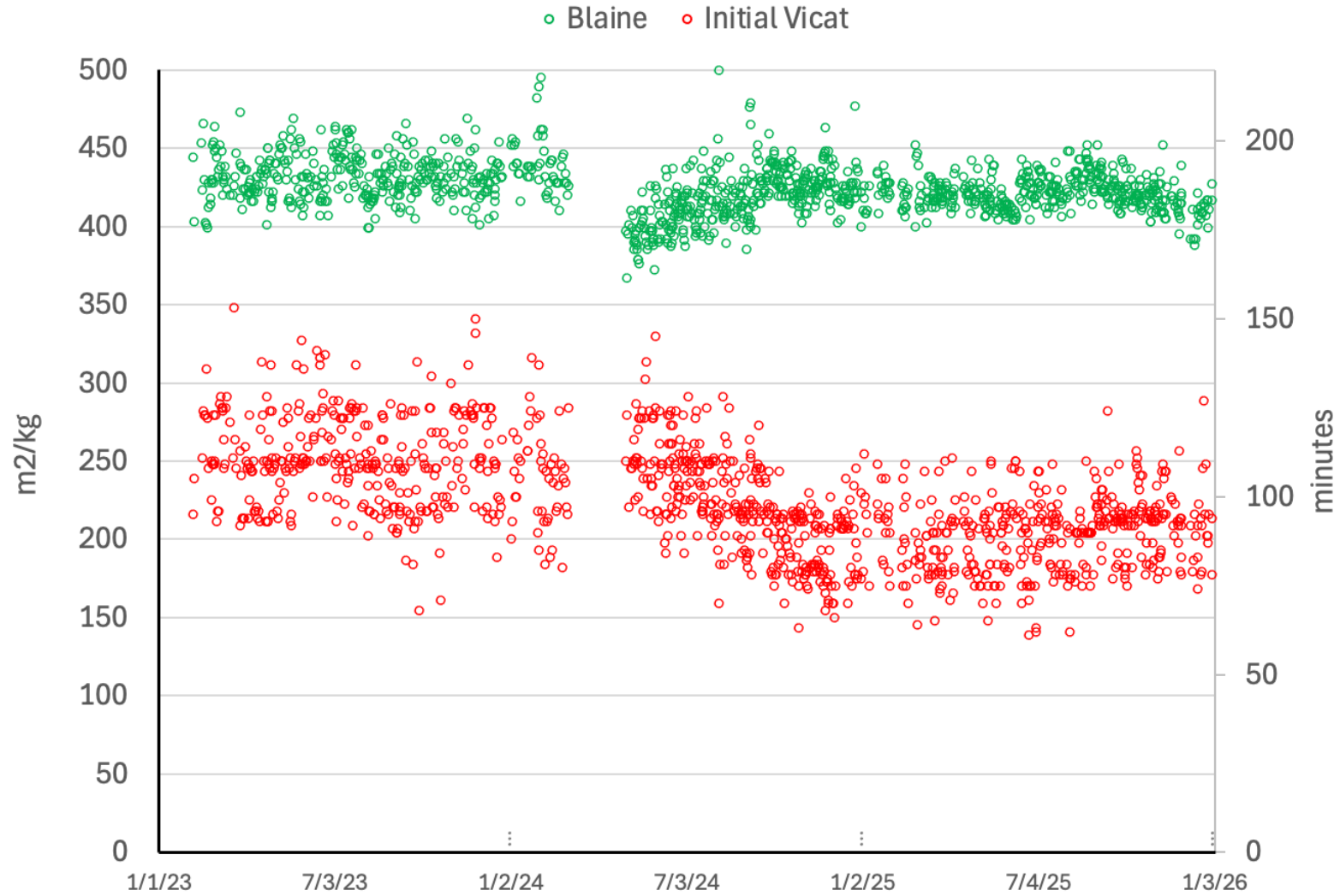
Plant 342 - Limestone & Strength



Plant 342 - Fineness & Strength



Plant 342 - Vicat & Blaine



Discussion – What's the data telling us?

- In the early stages (i.e., 2022-2023) variability can be seen
- HOWEVER, with very very few exceptions – the cement was meeting the specification even with the noted variation
- If we don't like the variation we are seeing – we need to change the specification
- **CAUTION:**
 - We do not have data that correlates the variation within the cement specification to variation in concrete
 - We may be chasing a ghost. i.e., Is the variation causing issues?

Discussion – What's the data telling us?

- Even with significant changes in target and limestone contents – the cements are meeting specification and cement performance – in terms of strength is for all practicality constant
- Time of initial set seems to be the property that needs closer attention and possibly reported more clearly
 - More data would help illuminate this issue
- Strength appears to be in control – no surprise because that is what is measured

Discussion – Path forward

- We can ask the producers for “more data”... but what?
- If the producers give users more data, what would they do with it?
- What do DOTs do with the data you currently get?
- How is it included in your day-to-day decisions?
- **GOAL: We need to know the material is “consistent”**
- How can we get this information – Control charts on the mill certs? If so what info? Limestone? Time of set?

Comments

- It's time to fish or cut bait
- **Are we as an industry going to innovate and move to lower clinker factor cements or not?**
- **Yes or No? Pick one.**



Comments

- If it's **NO** then we can go back to the days of plain portland cement where every yard of concrete was perfect and every next pound of cement was identical to the last



Comments

- If it's **YES** then start working together
- Neither side has been burning it up trying to use this process to find solutions
- Communicate (both ways)
- If we think there is a problem – document it – and engage all stakeholders to find a solution – work together
- If we think there is a solution, speak up – AND – listen, respectfully – AND – respectfully



Questions?

sutter.engineering@gmail.com

or

llsutter@mtu.edu

 sutter engineering llc

periculosum est tempus indoctus

