CLAIMS:

1. A system for determining a filter status, comprising:

a database configured to electronically store data, the data including past performance data of one or more water filtration elements; and

a processing device in communication with the database, the processing device is configured to:

receive as input the past performance data;

identify one or more data points within the past performance data indicative of a cleaning event for the one or more water filtration elements;

divide the past performance data into individual data segments, each of the individual data segments representing data of the past performance data in-between respective identified cleaning events;

fit a mathematical function to each of the individual data segments; and

identify a type of fouling occurring during each of the individual data segments based on the mathematical function fitted to the respective individual data segment.

2. The system of claim 1, wherein the processing device is further configured to normalize the past performance data to conditions at startup of the one or more water filtration elements before identifying the cleaning events.

3. The system of claim 1 or claim 2, wherein the processing device is further configured to account for a variation of at least one of a feedwater temperature, a feedwater composition, or a feed pressure, when normalizing the past performance data.

4. The system of any preceding claim, wherein the processing device is further configured to identify and remove physically inconsistent data points from the past performance data before identifying the cleaning events, wherein preferably the physically inconsistent data point is removed from the past performance data if the following conditions are not met:

feed flow is greater than concentrate flow;

the feed flow is greater than permeate flow;

feed pressure is greater than concentrate pressure; and

the feed pressure is greater than permeate pressure.

5. The system of any preceding claim, wherein the processing device is further configured to identify and remove statistical outlier data points from the past performance data before identifying the cleaning events, wherein preferably identifying and removing the statistical outlier data points from the past performance data comprises:

calculating a percentage change of a data point (y_t) from a previous data point (y_{t-1});

calculating a percentage change of a next data point (y_{t+1}) from the data point (y_t);

comparing a previous percentage change with a drop limit value; and

identifying the data point (y_t) as an outlier if the percentage changes exceed the drop limit.

6. The system of any preceding claim, wherein identifying the cleaning events comprises:

applying a differencing series method to a normalized pressure drop (dP) and a normalized permeate flow (Pf) from the past performance data, wherein applying the differencing series method includes:

calculating a difference between the data point (y_t) and the previous data point (y_{t-1}) to generate a differencing series for the normalized pressure drop (dP) and the normalized permeate flow (Pf);

calculating an average and a standard deviation for the differencing series for the normalized pressure drop (dP) and the normalized permeate flow (Pf);

comparing each value in the differencing series for the normalized pressure drop (dP) and the normalized permeate flow (Pf) to a sum of corresponding values in the differencing series and a product of a differencing constant and a corresponding standard deviation of the differencing series;

determining if a gap exists in the dataset; and

determining if the gap is wider than a CIP reference time.

7. The system of any preceding claim, wherein the processing device is further configured to analyze a coefficient of determination of the mathematical function and calculate derivatives of the mathematical function with respect to time, and wherein the processing device is further configured to identify the type of fouling based on the derivatives of the coefficient of determination.

8. The system of any preceding claim, wherein the one or more water filtration elements include at least one element selected from the group consisting of a reverse osmosis element, a nanofiltration element, and a hyperfiltration element.

9. The system of any preceding claim, further comprising one or more sensors configured to detect and transmit data for pressure drop, salt passage, and permeate flow associated with each of the one or more water filtration elements for storage in the database as the past performance data.

10. The system of any preceding claim, wherein:

the past performance data includes pressure drop, salt passage, and permeate flow for each of the one or more water filtration elements; and

if no change in the pressure drop, salt passage, and permeate flow is detected, the processing device identifies a no fouling condition; and/or, wherein:

the past performance data includes pressure drop, salt passage, and permeate flow for each of the one or more water filtration elements; and

if an increase in the pressure drop fits a 2^{nd} order polynomial function, the processing device identifies the type of fouling as biofouling; and/or, wherein:

the past performance data includes pressure drop, salt passage, and permeate flow for each of the one or more water filtration elements; and

if a decrease of the salt passage fits a 2^{nd} order polynomial function, the processing device identifies the type of fouling as organic fouling.

11. The system of any preceding claim, wherein:

the past performance data includes pressure drop, salt passage, and permeate flow for each of the one or more water filtration elements; and

if a steep increase in the pressure drop of first position elements fits a 1st order polynomial function, the processing device defines the type of fouling as particulate fouling; and/or, wherein:

the past performance data includes pressure drop, salt passage, and permeate flow for each of the one or more water filtration elements; and

if a gradual increase in the pressure drop of tail position elements fits a 1st order polynomial function, the processing device identifies the type of fouling as scaling; and/or, wherein:

the past performance data includes pressure drop, salt passage, and permeate flow for each of the one or more water filtration elements; and

if an increase in the permeate flow fits a 1st order polynomial function and an increase in the salt passage fits a 1st order polynomial function, the processing device identifies the type of fouling as an integrity failure event.

12. The system of any preceding claim, wherein the processing device is further configured to:

receive as input current performance data of the one or more water filtration elements as received from one or more sensors;

analyze the current performance data based on the previous analysis of the past performance data and the identification of the type of fouling occurring during each of the individual data segments;

estimate a current type of fouling occurring at the one or more water filtration elements; and

output a recommendation for a cleaning procedure specific to the current type of fouling occurring at the one or more water filtration elements.

13. The system of any preceding claim, further comprising artificial intelligence, machine learning capabilities, or both artificial intelligence, machine learning capabilities, wherein the artificial intelligence or machine learning capabilities operate to improve

identification of fouling types, predictability of fouling events or both identification of fouling types and predictability of fouling events.

14. A method for determining a filter status, comprising:

receiving as input to a system for determining a filter status past performance data of one or more water filtration elements, the system for determining the filter status including (i) a database configured to electronically store the past performance data, and (ii) a processing device in communication with the database;

identifying one or more data points within the past performance data indicative of a cleaning event for the one or more water filtration elements;

dividing the past performance data into individual data segments, each of the individual data segments representing data of the past performance data in-between respective identified cleaning events;

fitting a mathematical function to each of the individual data segments; and

identifying a type of fouling occurring during each of the individual data segments based on the mathematical function fitted to the respective individual data segment.

15. A non-transitory computer-readable medium storing instructions for determining a filter status that are executable by a processing device, wherein execution of the instructions by the processing device causes the processing device to:

receive as input to a system for determining a filter status past performance data of one or more water filtration elements, the system for determining the filter status including (i) a database configured to electronically store the past performance data, and (ii) the processing device in communication with the database;

identify one or more data points within the past performance data indicative of a cleaning event for the one or more water filtration elements;

divide the past performance data into individual data segments, each of the individual data segments representing data of the past performance data in-between respective identified cleaning events;

fit a mathematical function to each of the individual data segments; and

identify a type of fouling occurring during each of the individual data segments based on the mathematical function fitted to the respective individual data segment.