CLAIMS

1. An operation support device comprising

a computation unit to: calculate a cost of separation treatment that depends on a deterioration of a separation membrane using a cleaning efficiency model that expresses a deterioration of the separation membrane relative to the number of cleaning events, the separation membrane being configured to remove a removal target from sewage; calculate an operation cost using the cost of separation treatment, a cleaning cost for one cleaning event for the separation membrane, and a replacement cost for one replacement event for the separation membrane, the operation cost being a sum of the cost of separation treatment, a cleaning cost for the separation membrane, and a replacement cost for the separation membrane in an operation period of the separation membrane that is a period longer than a replacement cycle for the separation membrane; determine a first reference value and a second reference value such that the operation cost has a minimum value, the first reference value being used for determining whether to clean the separation membrane, the second reference value being used for determining whether to replace the separation membrane; and calculate a cleaning schedule and a replacement schedule for the separation membrane using the first reference value and the second reference value determined.

2. The operation support device according to claim 1, wherein

the computation unit

calculates the operation cost using:

water quality information on the sewage including a

concentration of the removal target and a flow rate;

an accumulation model that expresses an amount of foulant accumulation on a membrane surface of the separation membrane;

the cleaning efficiency model;

a maintenance cost including the cleaning cost for one cleaning event and the replacement cost for one replacement event; and

a power consumption model that expresses a power consumption that depends on a blockage rate of the separation membrane in a water treatment facility that performs the separation treatment.

3. The operation support device according to claim 2, wherein

the computation unit

changes an operating condition of a facility or device for maintaining a state of the separation membrane such that the operating condition satisfies a maintenance condition that is a condition for maintenance of the separation membrane, updates at least one of the accumulation model, the cleaning efficiency model, the maintenance cost, and the power consumption model based on the operating condition changed, and calculates the cleaning schedule and the replacement schedule.

4. The operation support device according to claim 3, wherein

the computation unit

changes an operating condition of a facility or device that is used for treatment at a pre-stage of the separation treatment such that the operating condition satisfies a maintenance condition that is a condition for maintenance

of the separation membrane, updates at least one of the water quality information, the accumulation model, and the power consumption model based on the operating condition changed, and calculates the cleaning schedule and the replacement schedule.

5. The operation support device according to any one of claims 1 to 4, wherein

the computation unit

calculates the operation cost in the operation period by calculating a time-series change of the blockage rate of a membrane using the first reference value and the second reference value and calculating the cost of separation treatment based on the time-series change of the blockage rate.

6. The operation support device according to any one of claims 1 to 5, wherein

the computation unit

determines the first reference value and the second reference value by calculating a plurality of the operation costs in the operation period for combinations of a plurality of first temporary reference values that are temporary values of the first reference value and a plurality of second temporary reference values that are temporary values of the second reference value and comparing the plurality of operation costs.

7. An operation support method comprising:

a calculation step of calculating a cost of separation treatment that depends on a deterioration of a separation membrane using a cleaning efficiency model that expresses a deterioration of the separation membrane relative to the

number of cleaning events, the separation membrane being configured to remove a removal target from sewage;

a reference value determination step of calculating an operation cost using the cost of separation treatment, a cleaning cost for one cleaning event for the separation membrane, and a replacement cost for one replacement event for the separation membrane, the operation cost being a sum of the cost of separation treatment, a cleaning cost for the separation membrane, and a replacement cost for the separation membrane in an operation period of the separation membrane that is a period longer than a replacement cycle for the separation membrane, and determining a first reference value and a second reference value such that the operation cost has a minimum value, the first reference value being used for determining whether to clean the separation membrane, the second reference value being used for determining whether to replace the separation membrane; and

a schedule calculation step of calculating a cleaning schedule and a replacement schedule for the separation membrane using the first reference value and the second reference value determined.