CLAIMS

1. A method, comprising:

introducing a feed stream having one or more solutes therein into a first side of a forward osmosis system;

circulating a draw stream through a second side of the forward osmosis system at a higher hydrostatic pressure and a higher osmotic pressure than the feed stream wherein a draw-to-feed osmotic pressure differential is at least 10 times higher than a draw-to-feed hydrostatic pressure differential;

generating a diluted draw stream in the second side of the forward osmosis system, the diluted draw stream having a higher water concentration than the draw stream; and

recovering a permeate from the diluted draw stream.

2. The method of claim 1 wherein the draw-to-feed osmotic pressure differential is at least 10 times higher than the draw-to-feed hydrostatic pressure differential along an entire membrane area of the forward osmosis system.

3. The method of claim 1, wherein circulating the draw stream through the second side of the forward osmosis system at the higher hydrostatic pressure than the feed stream includes circulating a marker in the draw stream.

4. The method of claim 3, wherein circulating the marker in the draw stream includes circulating the marker in a concentration at least 1000 times higher than a minimum detectable concentration of the marker.

5. The method of claim 3, wherein the marker includes one or more of fluorescein, methylene blue, pyrene, phthalocyanine, sulfate, fluoride, chloride, sodium, or rhodamine.

6. The method of claim 3, further comprising monitoring the feed stream, a permeate stream, or both for the marker.

7. The method of claim 6, further comprising adjusting one or more of a flow rate or a hydrostatic pressure of one or more of the feed stream or the draw stream based on said monitoring of the feed stream, the permeate stream, or both for the marker.

8. The method of claim 7, wherein said adjusting comprises maintaining, increasing, decreasing, or terminating the flow rate of one or more of the feed stream or the draw stream responsive to detecting the marker in the feed stream, the permeate stream, or both.

9. The method of claim 7, wherein recovering the permeate from the diluted draw stream includes circulating the diluted draw stream through at least one reverse osmosis element to separate water from the diluted draw stream to at least partially regenerate the draw stream and recover the permeate.

10. A method, comprising:

introducing a feed stream having one or more solutes therein into a first side of a forward osmosis system;

circulating a draw stream comprising a marker through a second side of the forward osmosis system at a higher hydrostatic pressure and higher osmotic pressure than the feed stream wherein a draw-to-feed osmotic pressure differential is at least 10 times higher than a draw-to-feed hydrostatic pressure differential;

generating a diluted draw stream in the second side of the forward osmosis system, the diluted draw stream having a higher water concentration than the draw stream;

recovering a permeate from the diluted draw stream;

concentrating the marker and the diluted draw stream to provide an at least partially regenerated draw stream; and

circulating the at least partially regenerated draw stream back to the second side of the forward osmosis system.

11. The method of claim 10, wherein the higher hydrostatic pressure of the draw stream is higher along an entire membrane area of the forward osmosis system.

12. The method of claim 10, further comprising monitoring the higher hydrostatic pressure.

13. The method of claim 10, wherein circulating the draw stream through the second side of the forward osmosis system at the higher hydrostatic pressure than the feed stream includes circulating the draw stream through the second side at a draw stream pressure about 2 psi to about 25 psi higher than a feed stream pressure of the feed stream.

14. The method of claim 10, wherein recovering the permeate from the diluted draw stream includes producing a permeate stream from the diluted draw stream, the permeate stream including water having at least a 2-log reduction in a concentration of the one or more solutes over the feed stream.

15. A system, comprising:

a forward osmosis system configured to receive a feed stream and a draw stream, the draw stream including a marker, the forward osmosis system further configured to produce a diluted draw stream;

a concentration system configured to concentrate the diluted draw stream and the marker and at least partially regenerate the draw stream including the marker;

a monitoring system positioned to monitor the feed stream, a permeate stream, or both for the marker; and

a pressure regulation system, the pressure regulation system configured to maintain the draw stream at a higher hydrostatic pressure than the feed stream in the forward osmosis system, wherein the pressure regulation system is in communication with the monitoring system, and wherein the pressure regulation system is further configured to adjust one or more of a flow rate or a hydrostatic pressure of one or more of the feed stream or the draw stream based on feedback from the monitoring system.

16. The system of claim 15, wherein the pressure regulation system is configured to maintain the higher hydrostatic pressure of the draw stream along an entire membrane area of the forward osmosis system.

17. The system of claim 15, wherein the monitoring system includes a detector configured to perform spectroscopy, fluorimetry, measure conductivity, or utilize a selective ion probe.

18. The system of claim 17, wherein the pressure regulation system is further configured to adjust one or more of a flow rate or a hydrostatic pressure of one or more of the feed stream or the draw stream based on the monitoring system detecting one or more of a flow rate, hydrostatic pressure, or a concentration or presence of the at least one marker in the feed stream.

19. The system of claim 15, wherein the pressure regulation system is configured to adjust by maintaining, increasing, decreasing, or terminating a flow of one or more of the feed stream or the draw stream responsive to an indication from the monitoring system of the marker in the feed stream.

20. The system of claim 15, wherein the concentration system comprises at least one reverse osmosis element configured to separate water from the diluted draw stream to at least partially regenerate the draw stream and recover a permeate.

21. The system of claim 15, further comprising an additional draw stream source positioned to add additional draw stream to the diluted draw stream, the at least partially regenerated draw stream, or both, to reduce contaminant concentration in the at least partially regenerated draw stream.