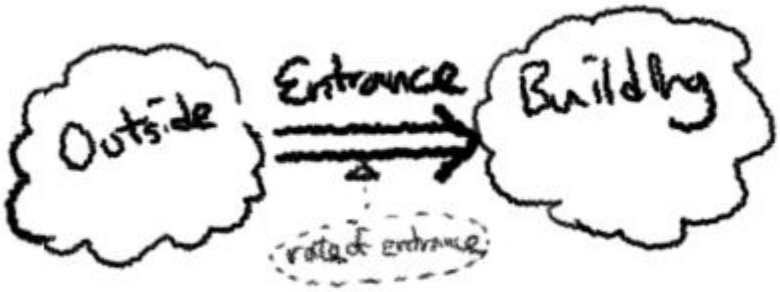
ModSim Exercise 2

Jamie Cho

2.1)

1. Constant flows
   A. Given sufficient number of people wanting to enter a building, and finite number of known entrance, and the building spatial enough to contain every person -- in terms of modeling, this implies sources (people outside), sinks (building), and regulated rate of inflow (entrance), the inflow of people to the building will be constant.



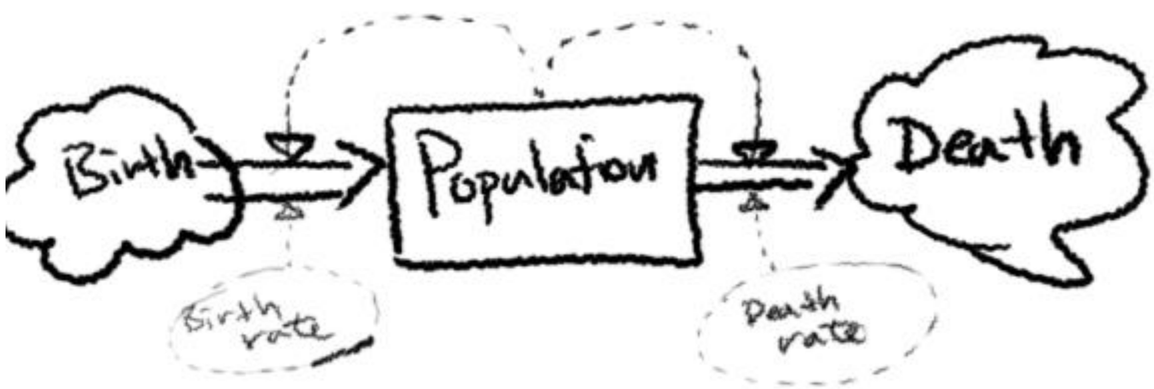
   B.
   C. $\mathrm{E} = \frac{dP}{dt} = r_e$ (const. var.)
      - Units

        E: Entrance Flow, kg/minute

        P: Biomass of persons, kg

        t: Time, minute

        Although number of person is a discrete quantity, and so would be the flow, with adequate number of people and mathematical assumptions, a continuous model can be adopted.
2. Flows proportional to single stock
   A. The inflow (birth) and the outflow (death) of people depends on the size of human population.



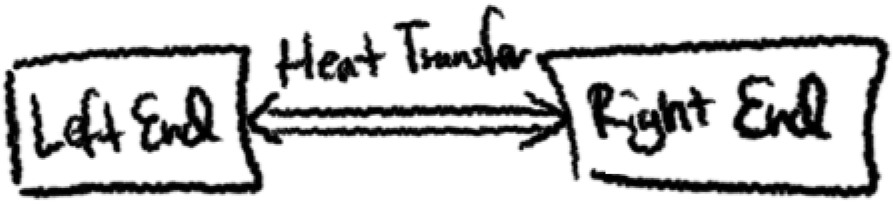
   B.
   C. $\frac{dP}{dt} = B(P) - D(P) = k_b P - \ k_d P$
      - Units

        P: Biomass of the population, Metric Tons

        t: Time, year

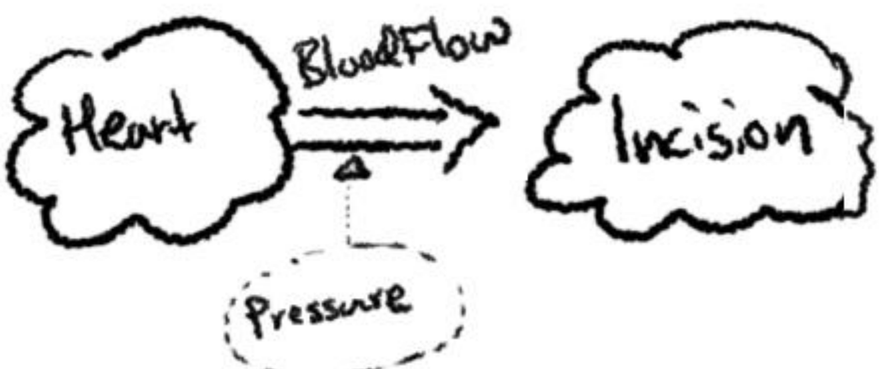
B: Birth, Metric Tons/year
D: Death, Metric Tons/year
k_b: Birth rate const., unitless scalar
k_d: ,Death rate const., unitless scalar

3. Flows proportional to the difference between two stocks
   A. The heat flow in a conductible material is dependent on the magnitude of enthalpy(amount of thermal energy) on either ends.



   B.
   C. $Q = \frac{dE}{dt} = k_T \Delta E = k_T(E_L - E_R)$
      - Units
        Q: Heat, Joules/second
        E: Enthalpy, Joules
        t: Time, seconds
        k_T: Heat transfer constant, unitless scalar (for the purposes of modeling)
        E_L: Enthalpy of the Left end, Joules
        E_R: Enthalpy of the Right end, Joules

4. Non-monotonic flows
   A. The flow of blood from an incision in the artery, which would depend on the pressure of blood outflow as dictated by the heart.



   B.
   C. $\frac{dB}{dt} = F_B(P)$
      - Units
        B = Blood, Liters
        t = Time, seconds
        F_B = Flow of Blood, Liters/second
        P = Pressure, external variable dependent on factors such as time.

5. Flows that depend on time
   A. The inflow of the biomass of salmon stock depends on time, as its reproduction occurs seasonally – the "salmon run" occurs during the fall, September through November.

   B.
   C. $\frac{dP_S}{dt} = B(s(t), P_S) - D(P_S)$

      Units

      P_S = Biomass of Salmon, Metric Tons

      t = Time, month

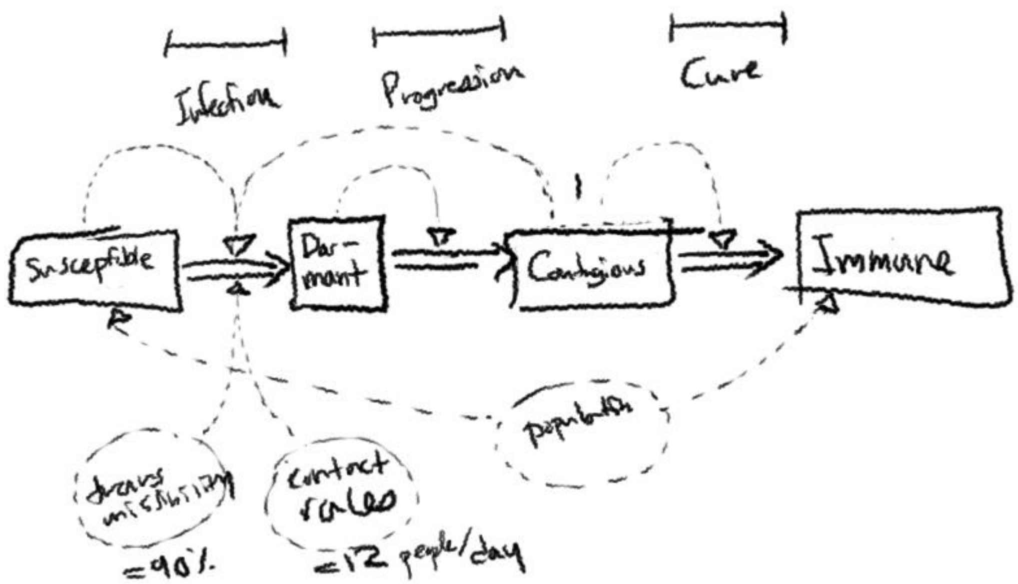
      B = Birth flow, Metric Tons/month

      s = season (arbitrary variable)

      D = Death (or Biomass dissipation due to death) flow, Metric Tons/month

2.2)

1.



2.

$$F_I = \frac{dS}{dt} = C * k_r * k_t * \frac{S}{P}$$

$$F_P = \frac{\mathrm{dD}}{\mathrm{dt}} = \mathrm{D}(13), \mathrm{F}_C = \frac{dC}{dt} = C(9)$$

Which is equivalent to:

Infection flow = Contagious *Contact Rates*(Transmissibility*Susceptible/Population)

Progression flow = Population at 13^{th} day of Dormant Population

Cure flow = Population at 9^{th} day of Contagious Population

Data Plots:

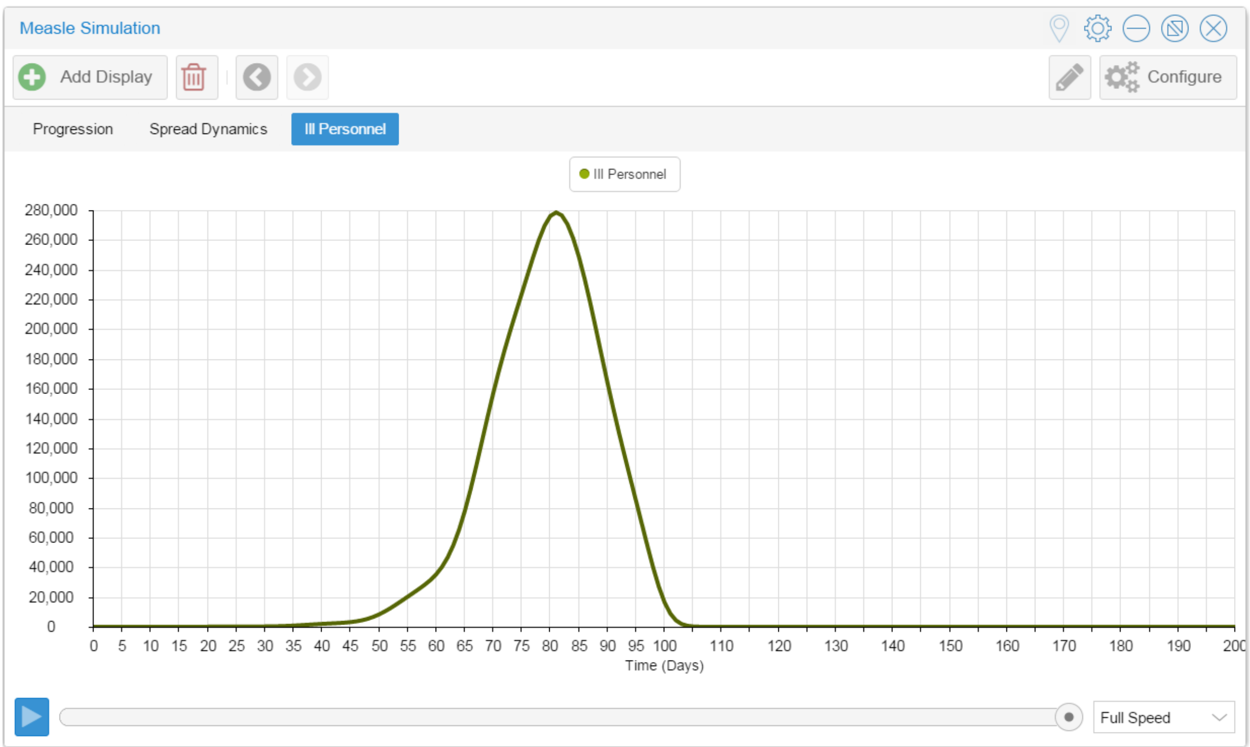


Figure 1. The time series of the number of Ill Personnel.

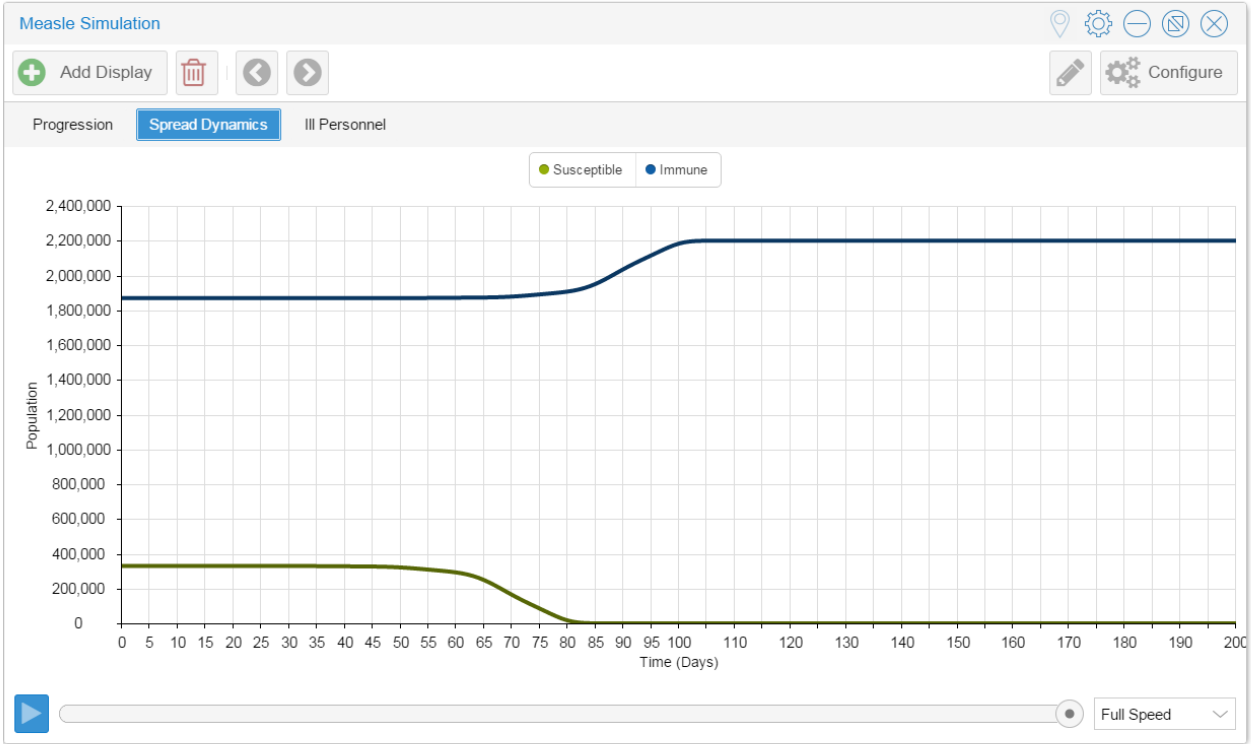


Figure 2. The Times series that illustrates the transition in population dynamics with respect to measles.

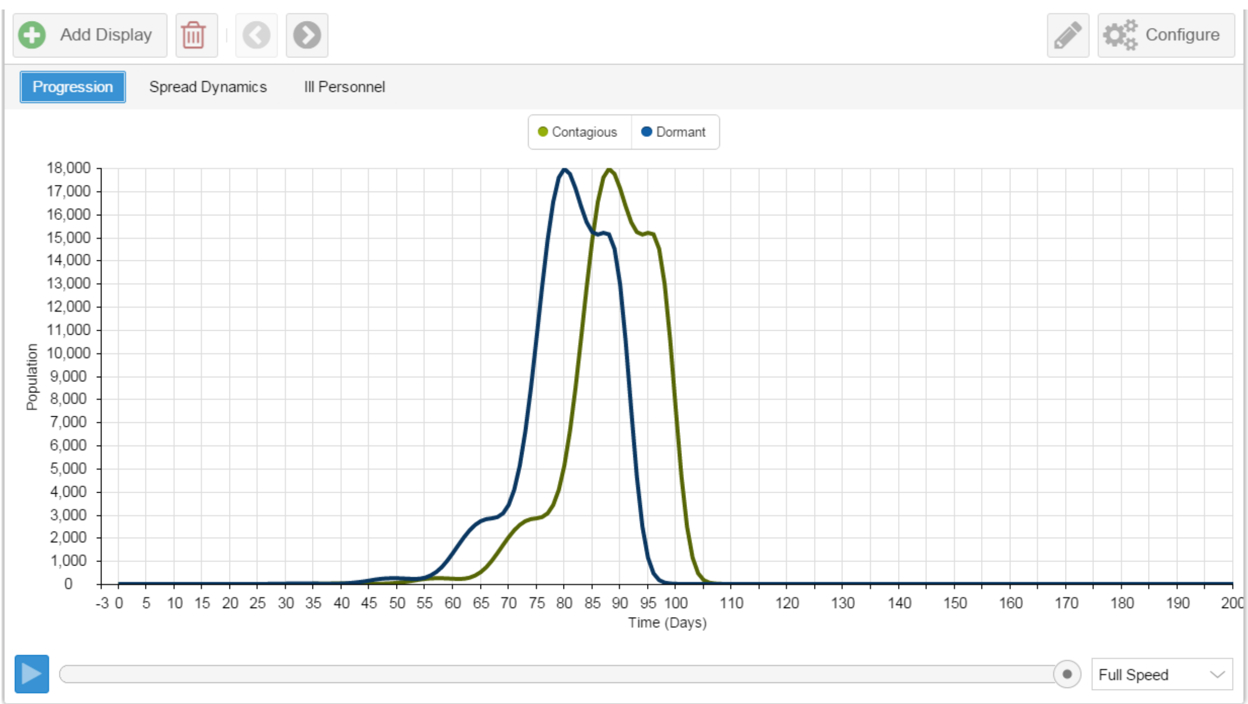


Figure 3. The Time series that depicts the intimate relationship between contagious and dormant persons.

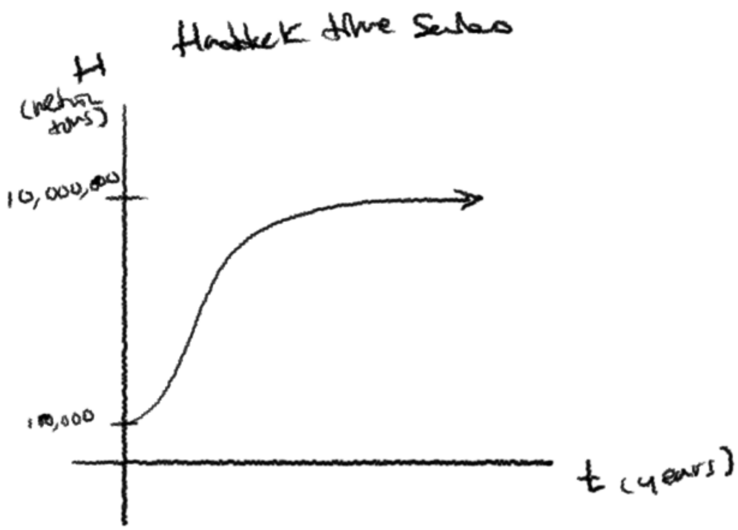
3.

In my implementation, the epidemic peaks the 81st day with 278,518 persons affected. After the 111th day, the number of ill personnel was zero; after the 90th day, no more spread of the disease was observed, and all but 1 of the population had undergone the process of the disease. Although this does not match practical data from experience, this model is based on the assumption that afflicted persons freely interact with any of the population – and fails to take into account the societal efforts to thwart the disease, which serves as an adequate explanation of why this model might fail to reflect on the reality.

When I altered the immunization percentage from 85% to 90%, 163,611 persons were ill on the 96th day (Peak). This is not only a display of delaying the spread of the disease – which provides longer time to prepare and counteract the epidemic – but also the evidence of greatly reduced severity. On the other hand, when I limited the contact rates from 12 persons a day to 6 persons a day, greater delay in time – peaking at the 113th day – was observed, with 214939 persons ill. Thus, it seems that the contact rates have greater effect in delaying the propagation of the disease than reducing its severity, which is logically coherent with intuition.

2.3)

1.



2. The time series looked congruent, with minor discrepancies in curvature magnitude.

3.

update_haddock.m

```
%precondition : varialbe H represents Haddock Stock
% g is the growth rate constant,
% and K is the carrying capacity. (same conventions from exercise)
% the units are in metric tons, per year.
```

```
H = H + g*H*(1-H/K);
%postcondition : H now contains the changed Haddock Stock after an year.
```

plot_haddock.m

```
H = 100000; %metric tons
K = 10000000; %metric tons
g = 0.10; % years^-1
hold on
for i = 0:100
   plot(i,H,'*');
   update_haddock;
end
```

The two plots looked nearly identical.

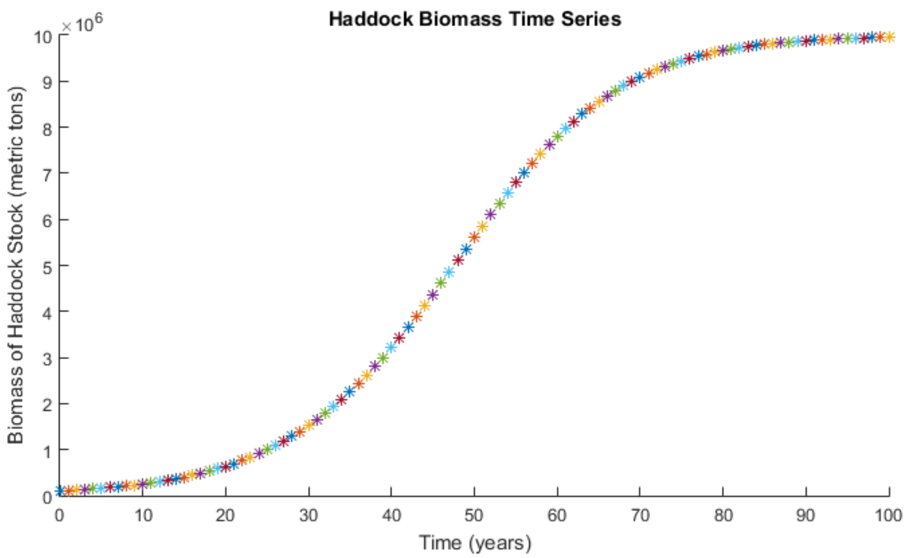


Figure 2. Matlab Time Series

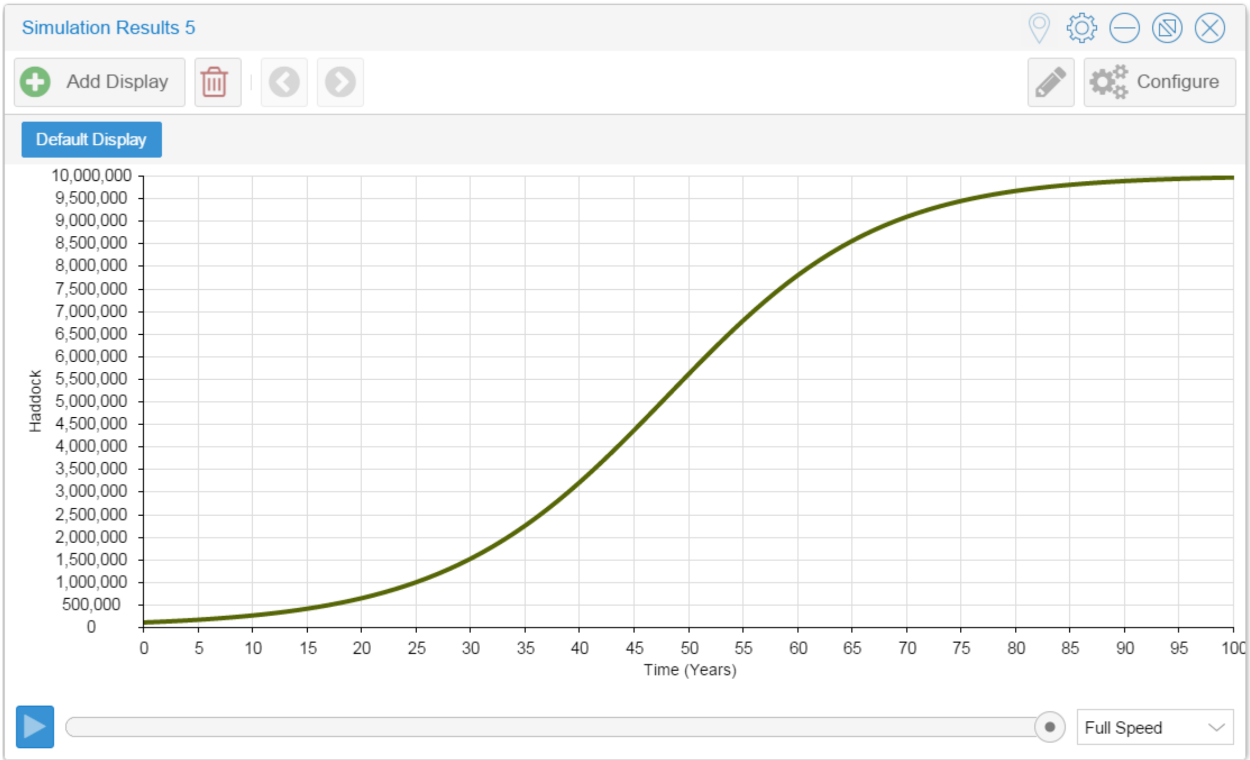


Figure 3. Insight Maker Time Series