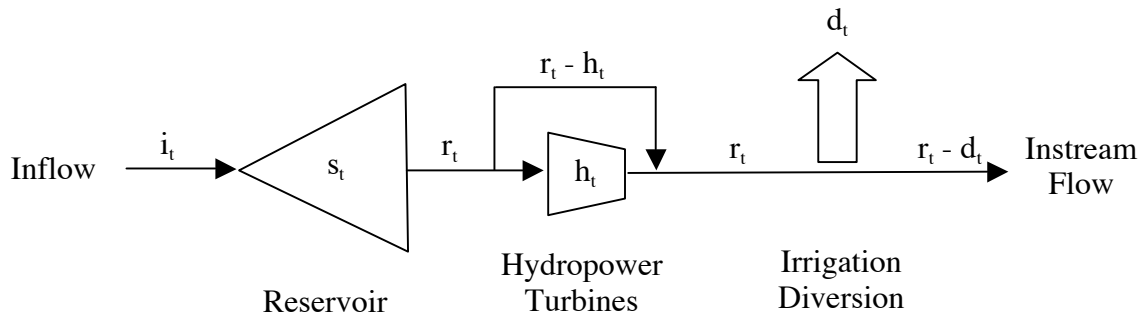


Reservoir Operation Problem

ENVR 104 – Water Resource Management module



(Adapted from *Water Resources Engineering*, Wurbs and James, 2002)

where,

- t = monthly counter, $t = 1, 2, \dots, 12$;
- i_t = monthly inflow (million m^3);
- s_t = monthly storage (million m^3);
- r_t = monthly release from reservoir (million m^3);
- h_t = monthly flow diverted through hydropower turbines (million m^3);
- d_t = monthly flow diverted to irrigation (million m^3).

Water releases from a storage reservoir provide three types of services (i) hydropower generation; (ii) supply water to irrigators downstream; and (iii) habitat and recreational opportunities to downstream users. The local water authority is trying to determine a schedule of water releases that will maximize the revenue generated through hydropower production and irrigated agriculture, while maintaining the instream flows necessary for environmental and recreational uses. The hydroelectric turbines can accommodate as much as 180 million m^3 /month; flows in excess of this amount bypass the turbines. Irrigators require water only 6 months out of the year, with the upper limits on monthly irrigation demand listed in the attached table. Instream flow requirements are set at 20 million m^3 /month. Reservoir storage capacity is 600 million m^3 . Revenues from crops produced via irrigation water translate to \$900 per million m^3 used, while each million m^3 used to generate hydropower produces \$400 in revenue (in some instances the same unit of water can be used for both purposes).

The objective of this problem is to determine the set of monthly reservoir releases that will maximize revenue while maintaining instream flows at the required level. Develop a linear program using LINDO software (a 30 day trial version can be obtained at www.lindo.com) or another LP solver and develop a solution. Produce a short writeup (a Results Table plus 1 pg, of discussion single-spaced) describing your results.

When developing the LP, think carefully about the formulation of the objective function and the development of the mass balance constraints, as well as the constraints that apply to storage capacity, hydropower production, instream flows, and irrigation demand (with respect to the irrigation demand, keep in mind that it does not have to be met, but exceeding demand makes little sense). Also, remember that all constraints need to be explicit with respect to the time period in which they apply (i.e. $s_1 \leq 600$ million m^3 , $s_2 \leq 600$ million m^3 , $s_3 \leq \dots$)

ENVR 104

Water Resource Management Module

LP Reservoir System Example

Month	t	Known Data		Calculated Values		Optimal Decision Values		Revenue (\$)
		Inflow (million m3) i(t)	Irrigation Demand (million m3) a(t)	Total Release (million m3) r(t)	End of Month Storage (million m3) s(t)	Hydropower Release (million m3) h(t)	Irrigation Diversion (million m3) d(t)	
		s(0) = 115						
January	1	95	0					
February	2	112	0					
March	3	170	0					
April	4	250	0					
May	5	265	50					
June	6	62	150					
July	7	35	260					
August	8	18	260					
September	9	55	190					
October	10	88	100					
November	11	85	0					
December	12	90	0					

Capacity = 600

Revenue = \$400 per million m3 \$900 per million m3 **Total Revenue:** 0