European Bank for Reconstruction and Development

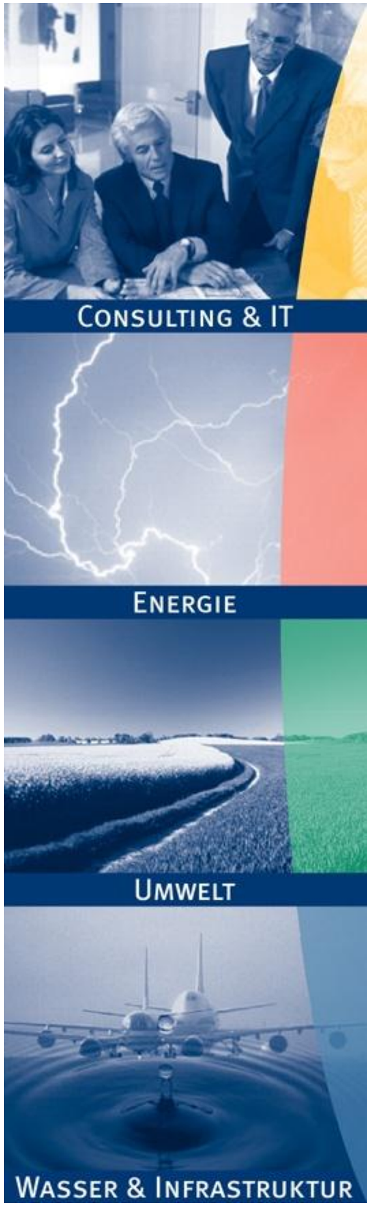
FICHTNER

Economical Optimization of Installed Capacity of a Small Hydropower Plant

Case Study Gegharot SHPP, Armenia

Training Workshop “EBRD: Financing Small Hydropower Plants in Ukraine”

Kiev, 05.10.2011



Program

- Due Diligence of a Small Hydropower Plant,
  Case Study Las Pizarras HPP, Peru
- Economical Optimization of Installed Capacity of a Small Hydropower Plant
  Case Study Gegharot SHPP, Armenia
- Chances and Risks from Pre-Feasibility Study to Operation
- Questions and Discussions

Overview

Introduction

Lay Out Design of Small HPP's

Previous Practice

Standard Practice

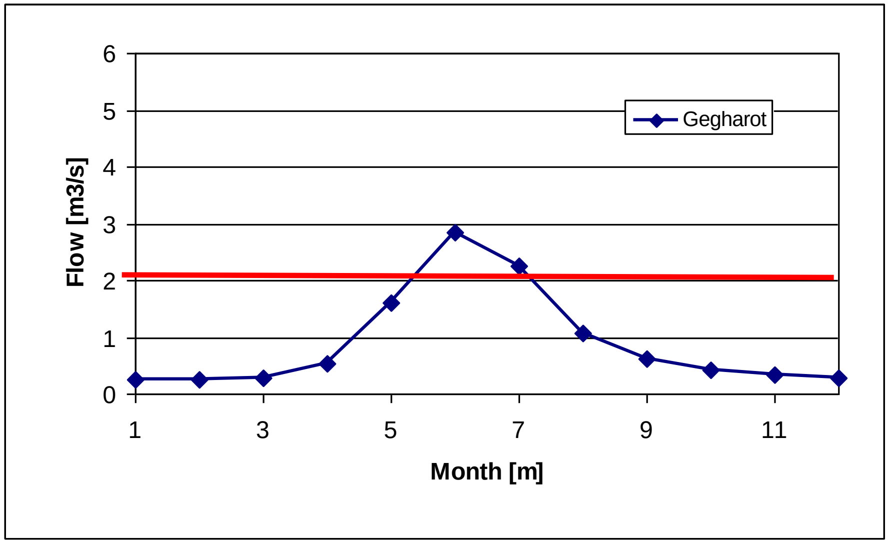
- Range of Design Discharges
- Estimation of Costs
- Calculation of Power/Energy/Benefits for various Design Discharges
- Determination of Design Discharges

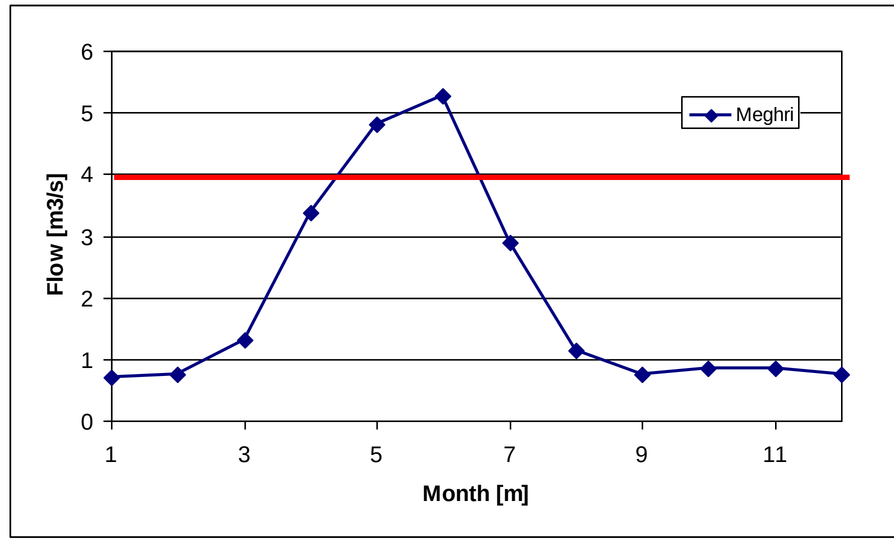
Determination of Design Discharge

Case Study Gegharot, Armenia

Layout Design Previous Practice

Maximization of Energy





Q_d = 2.1 m³/s

Gegharot SHPP

Q_d = 4.0 m³/s

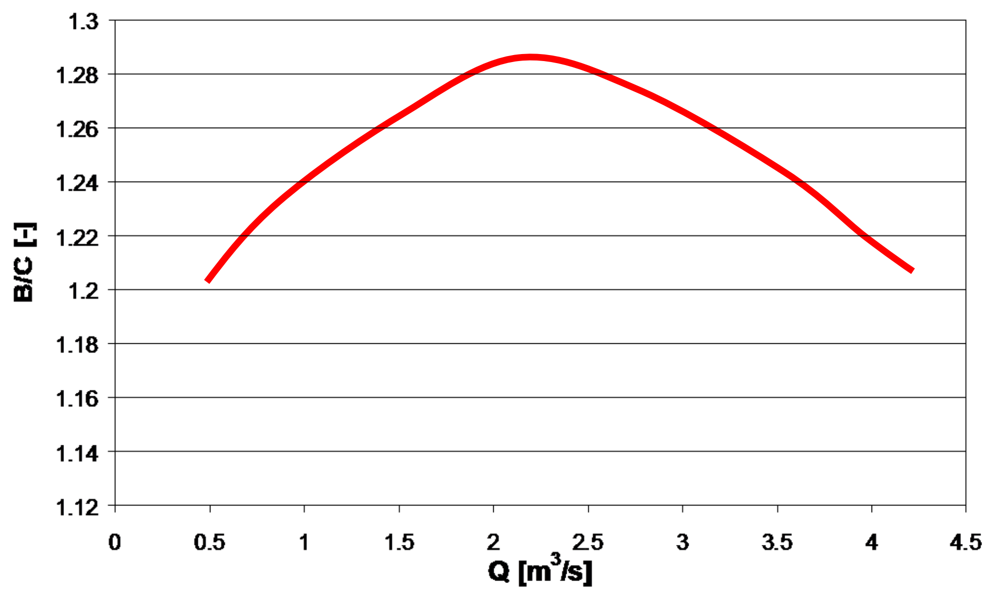
Meghri SHPP

No Consideration of Economical Issues

Layout Design Standard Practice

Development of Benefit-Cost-Ratio for various Design Discharges

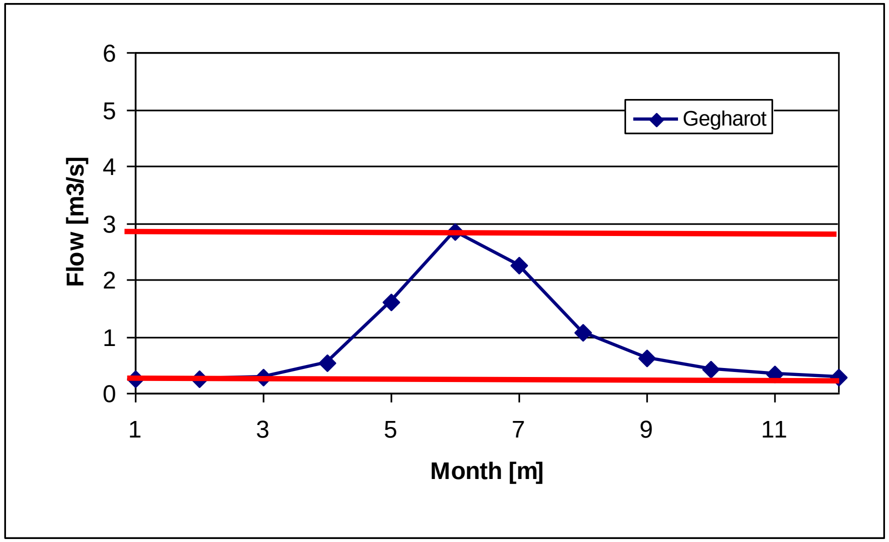
$B/C = f(Q_d)$

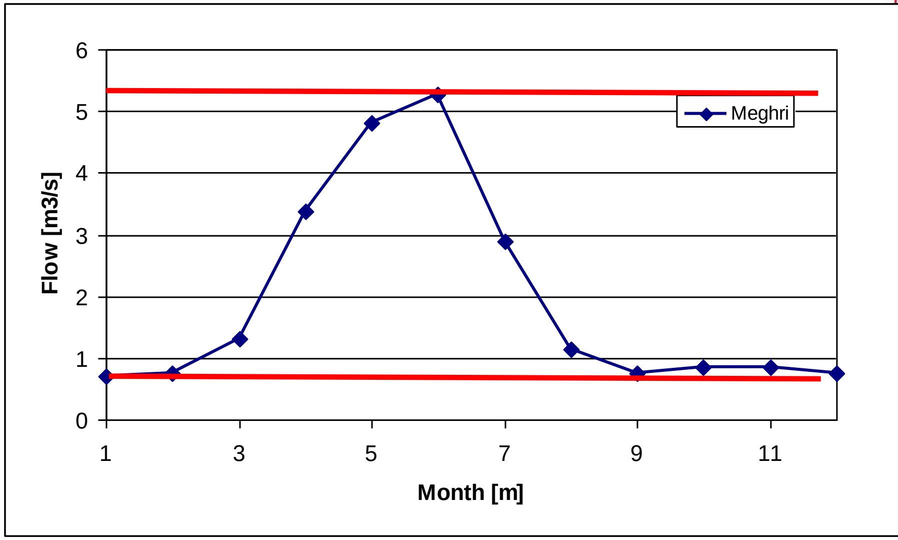


- Various DESIGN DISCHARGES
- COST
- BENEFIT depending on ENERGY

Layout Design Standard Practice

Range of Design Discharges





$Q_{min} < Q_d < Q_{max}$

$0.4\ m^3/s < Q_d < 2.8\ m^3/s$

$Q_{min} < Q_d < Q_{max}$

$0.8\ m^3/s < Q_d < 5.2\ m^3/s$

Layout Design Standard Practice

Estimation of COSTS for various Design Discharges

Design Discharge [m^3/s]	Civil Works, [TUS$]	Hydro-mechanical Equipm., [TUS$]	Electrical Equipm., [TUS$]	Direct cost, [TUS$]	Total cost, incl. Phys. Cont. [TUS$]	Total Costs incl. O & M [TUS$]
0.4	1083	734	57	1873	2061	2212
0.6	1606	822	66	2494	2744	2945
0.8	1616	1064	75	2754	3030	3252
0.9	1929	1120	79	3128	3441	3694
1.0	1934	1013	82	3030	3333	3578
1.2	2316	1101	90	3506	3857	4140
1.3	2319	1141	92	3552	3907	4194
1.4	2323	1356	94	3773	4150	4455
1.5	2708	1397	96	4201	4621	4961
1.6	2713	1439	98	4250	4674	5017
1.8	3138	1518	101	4757	5233	5617
2.0	3149	1596	105	4851	5336	5728
2.1	3153	1637	107	4898	5387	5782

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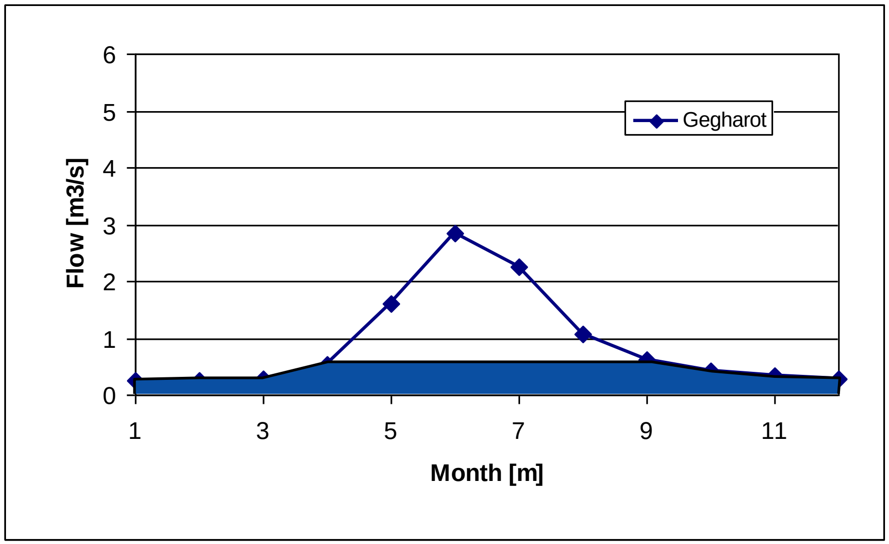
Layout Design Standard Practice

Calculation of POWER/ENERGY/BENEFITS for various Design Discharges



Q_d = 0.4 m^3/s

P = 1030 kW

E = 6.17 GWh

↓

Tariff = 0.045 US$/kWh

↓

Benefit (1 year) = 277.6 TUS$

↓

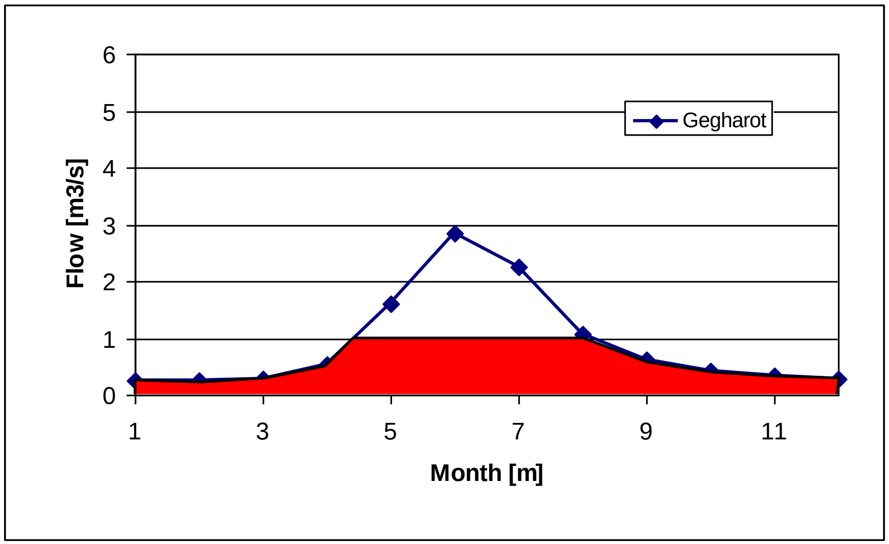
Benefit (30 years) = 2.618 MUS$

Costs = 2212 MUS$

B/C = 1.183

Layout Design Standard Practice

Calculation of POWER/ENERGY/BENEFITS for various Design Discharges



Q_d = 1.0 m^3/s

P = 2730 kW

E = 11.13 GWh

↓

Tariff = 0.045 US$/kWh

↓

Benefit (1 year) = 500.8 TUS$

↓

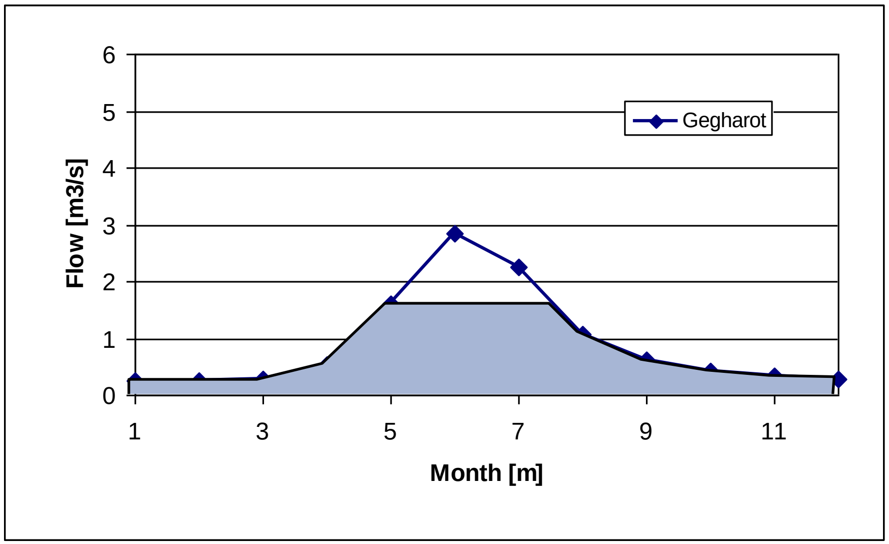
Benefit (30 years) = 4.723 MUS$

Costs = 3.578 MUS$

B/C = 1.32

Layout Design Standard Practice

Calculation of POWER/ENERGY/BENEFITS for various Design Discharges



Q_d = 1.6 m^3/s

P = 4420 kW

E = 14.0 GWh

↓

Tariff = 0.045 US$/kWh

↓

Benefit (1 year) = 630.0 TUS$

↓

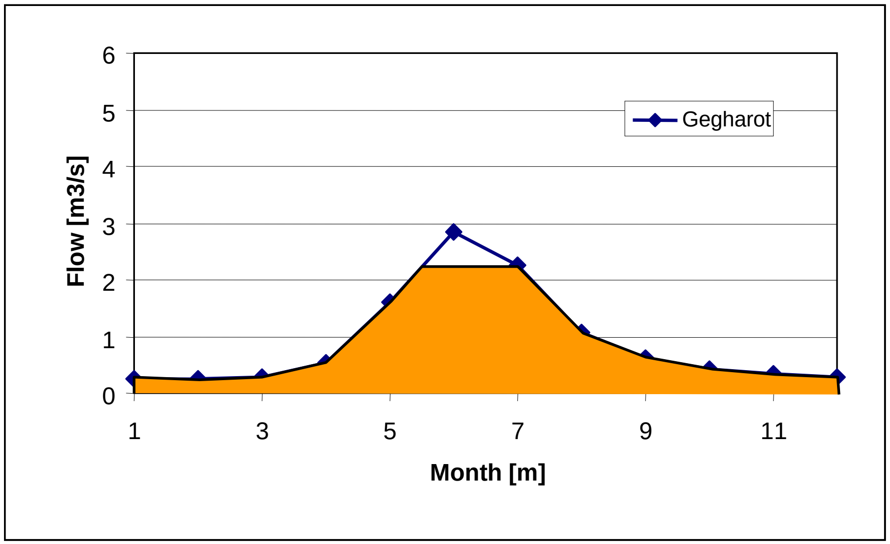
Benefit (30 years) = 5.941 MUS$

Costs = 5.013 MUS$

B/C = 1.185

Layout Design Standard Practice

Calculation of POWER/ENERGY/BENEFITS for various Design Discharges



Q_d = 2.1 m^3/s

P = 5140 kW

E = 15.6 GWh

↓

Tariff = 0.045 US$/kWh

↓

Benefit (1 year) = 702.0 TUS$

↓

Benefit (30 years) = 6.62 MUS$

Costs = 5.701 MUS$

B/C = 1.145

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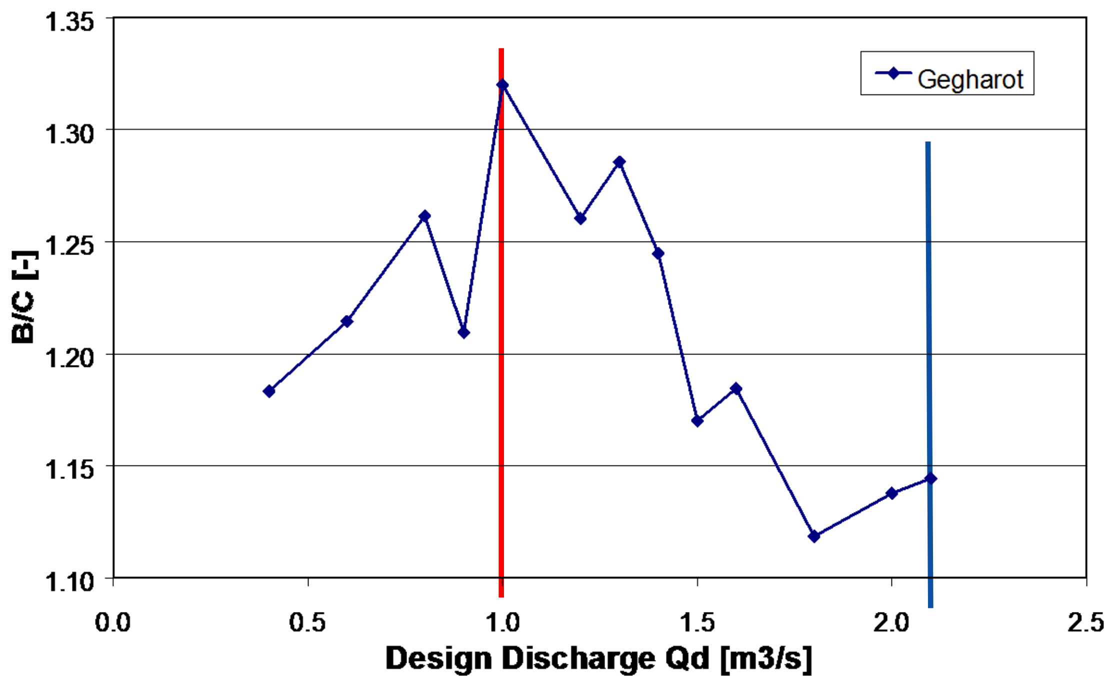
Determination of Design Discharge to Q = 1.0 m^3/s



B/C is max at Q = 1.0 m3/s **Previous List: Q = 2.1 m3/s**

Optimization of Installed Capacity

Gegharot

Most efficient use of energy

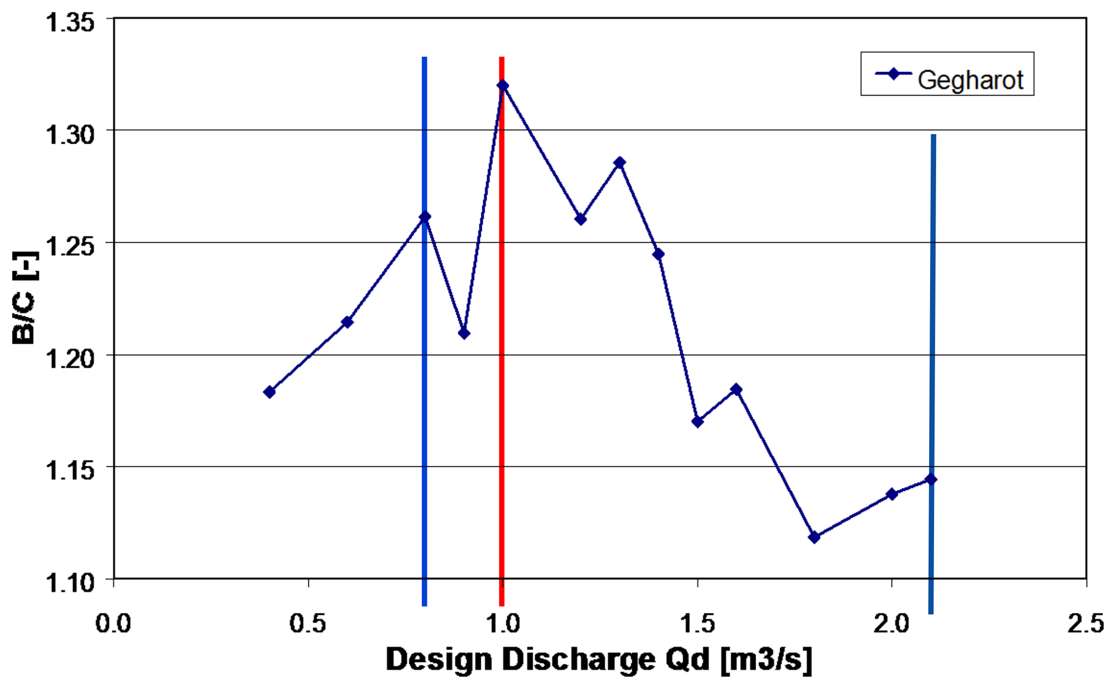
Maximum Profitability

Less energy

Less profitability

Easier Financing

Spoil of natural resources



More energy

Less profitability

Difficult Financing

Risk of non development

Private Interest	Optimum	Previous Design
Qd = 0.8 m3/s	Qd = 1.0 m3/s	Qd = 2.1 m3/s