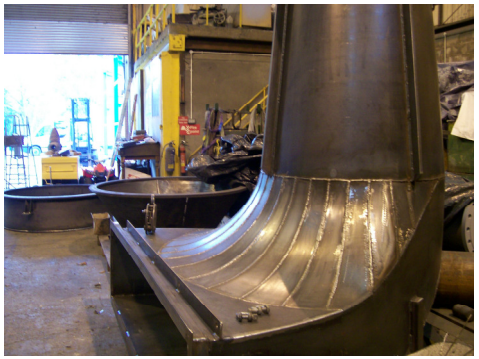
LANCASTER UNIVERSITY

Terry McGuire & Phil Leigh

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

New Mills Hydro



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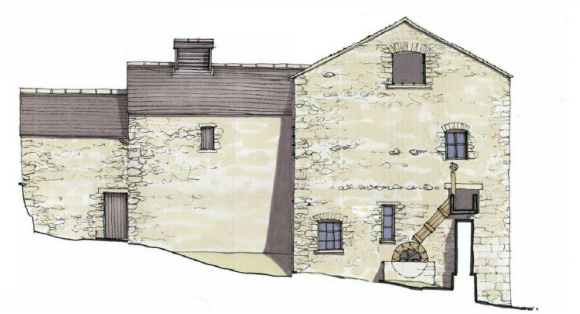
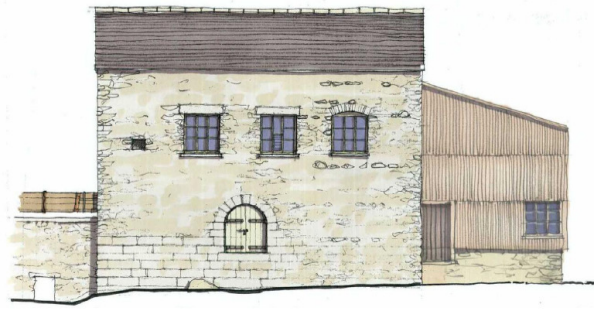
nht

ENGINEERING
WATER TURBINES



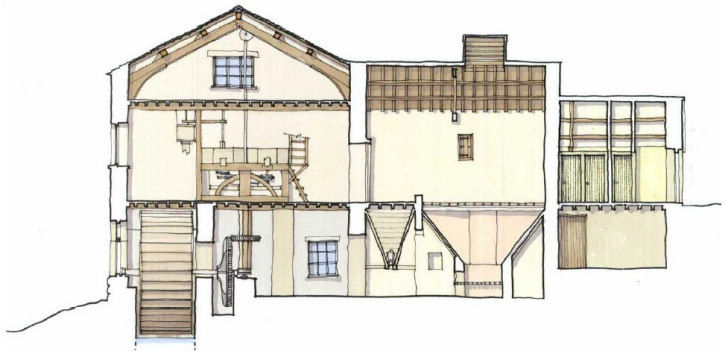


Heron Corn Mill

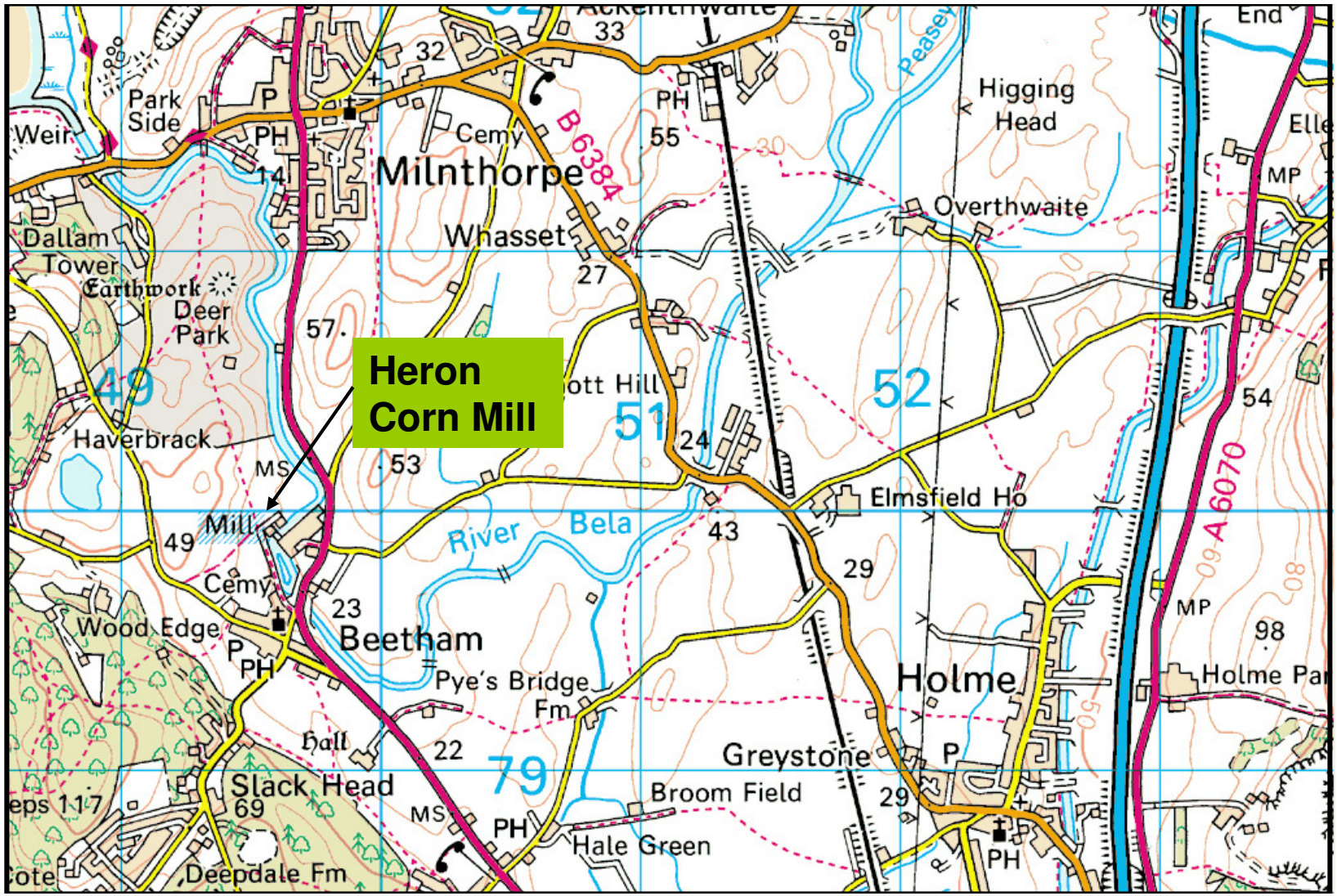
(case study)

Crichton carbon centre Dumfries

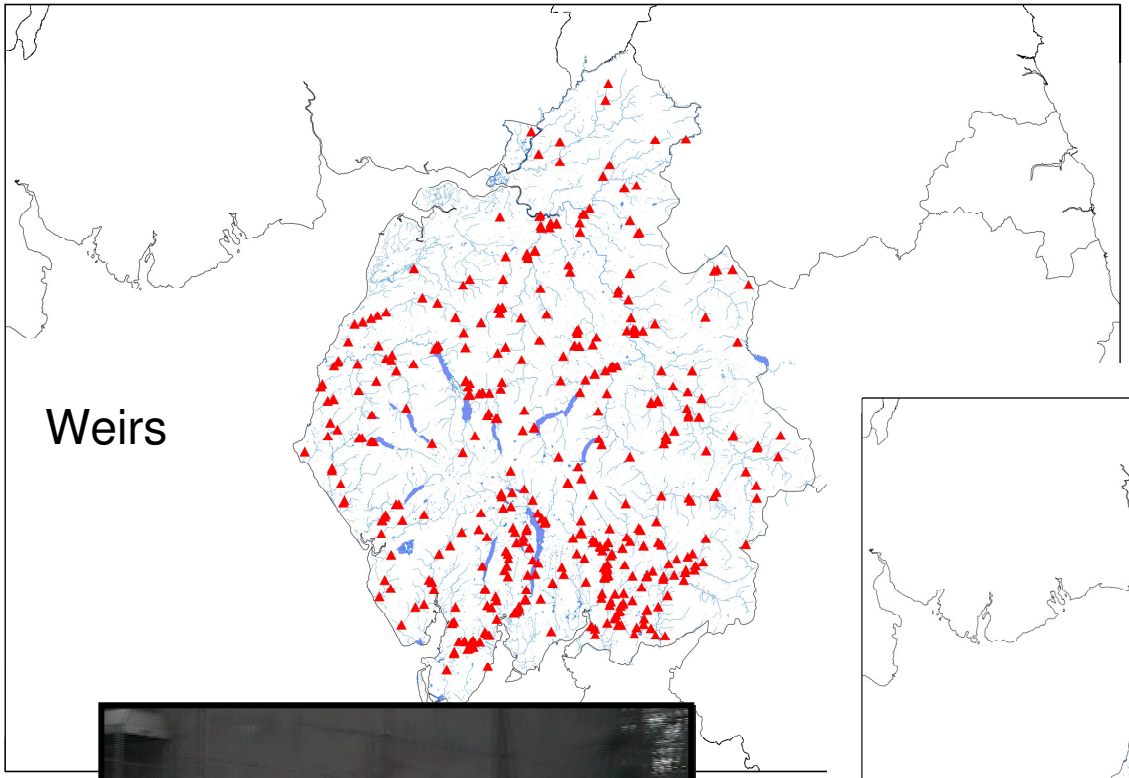
Heron Corn Mill, Beetham

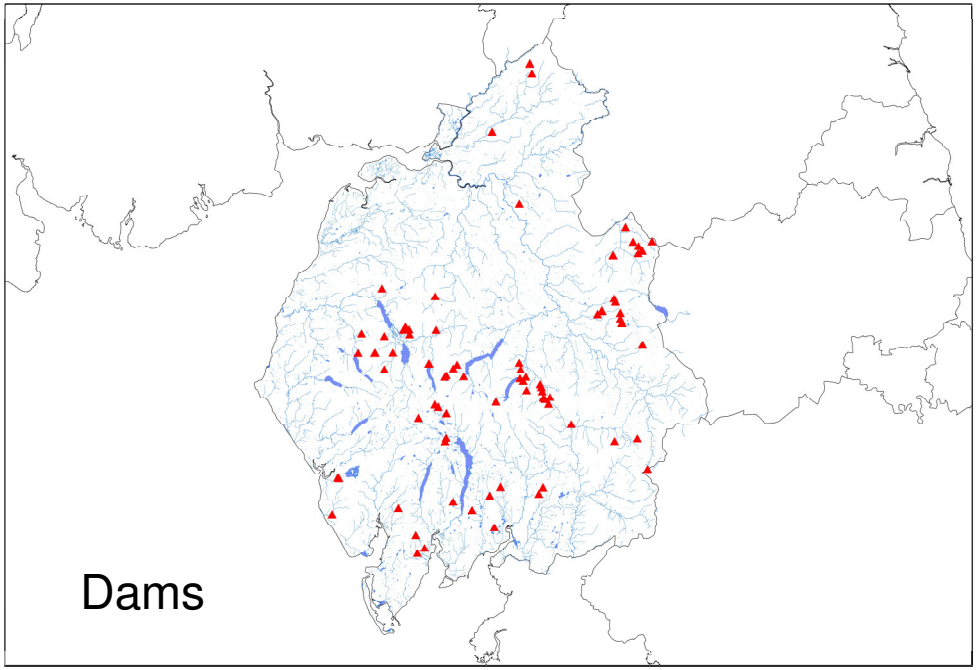


Beetham, Cumbria

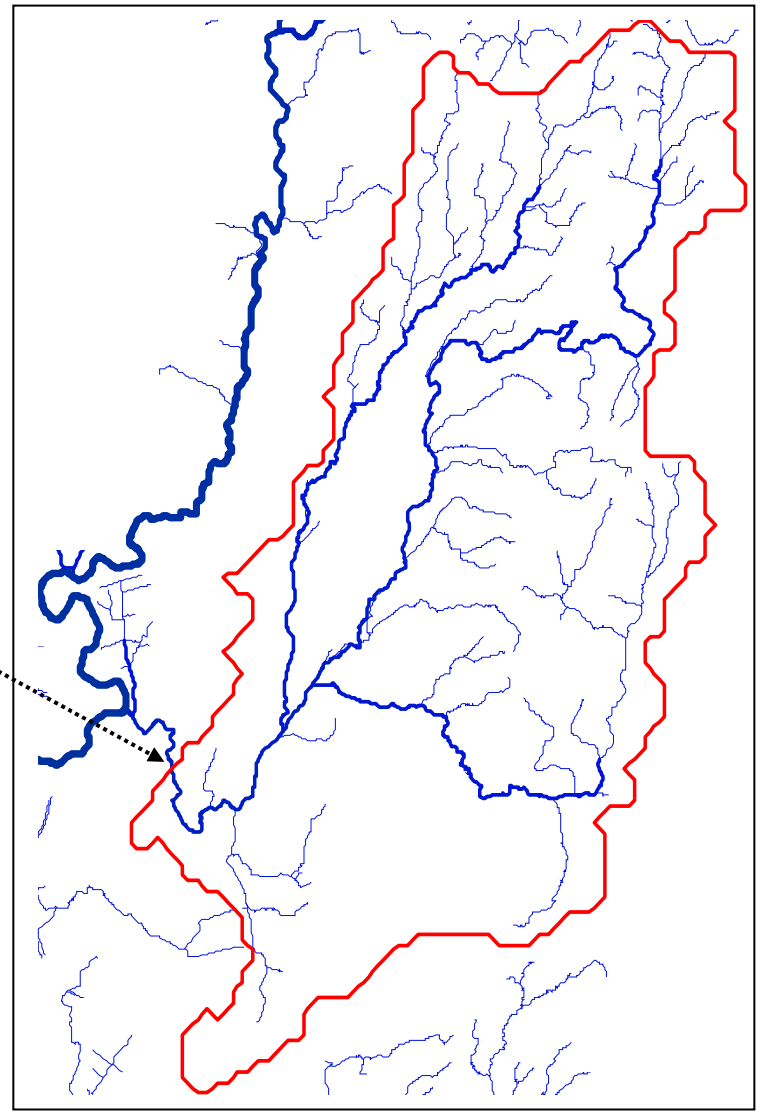


Historical water use in Cumbria





River Bela, Beetham



Bela Catchment

Solid Geology: Silurian Slate with Carboniferous Limestone in lower reaches

Drift Geology:
70% Boulder Clay

Land use:
70% Arable farming & permanent grassland

30% Rough grazing

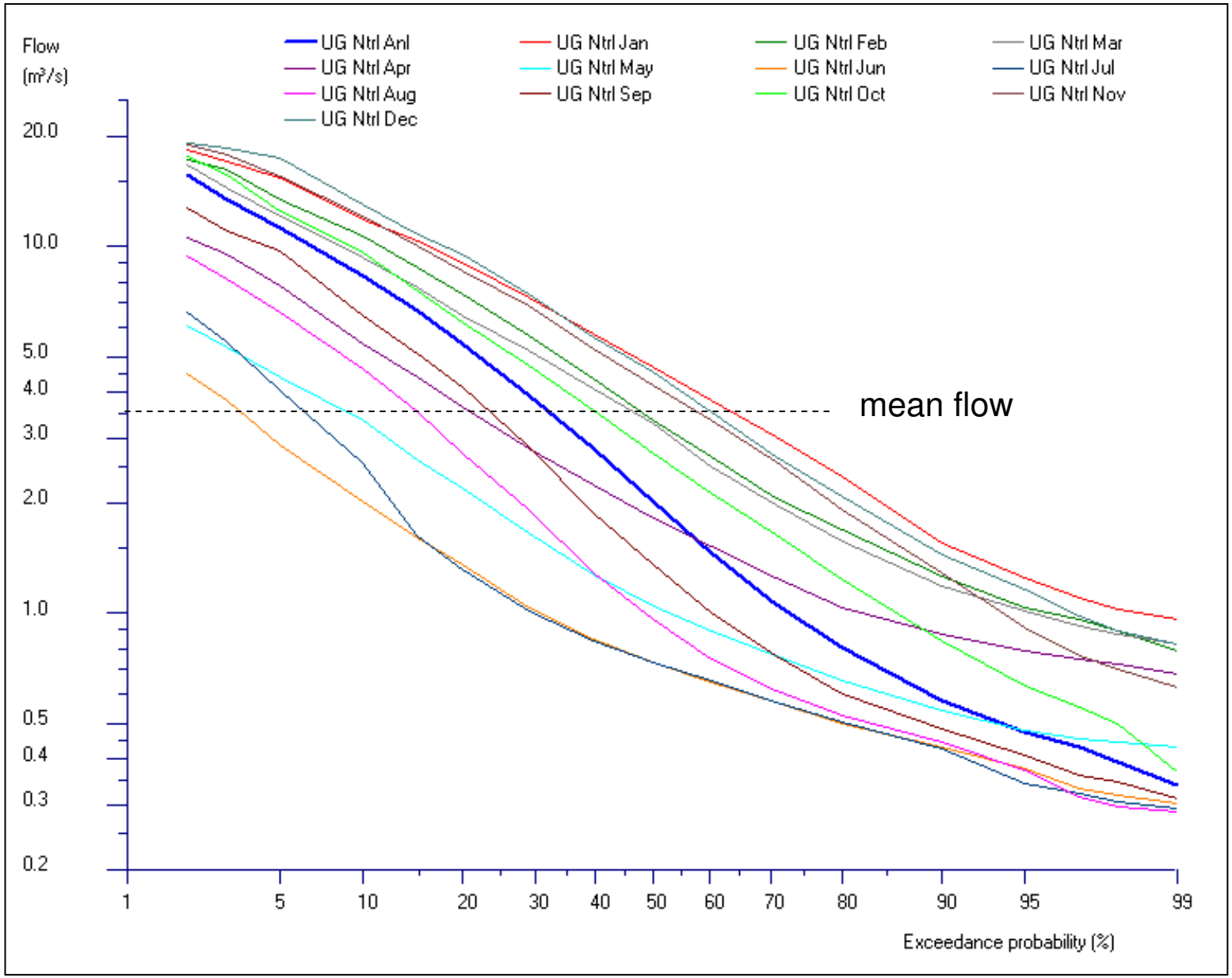
River Bela basin details

Basin details:

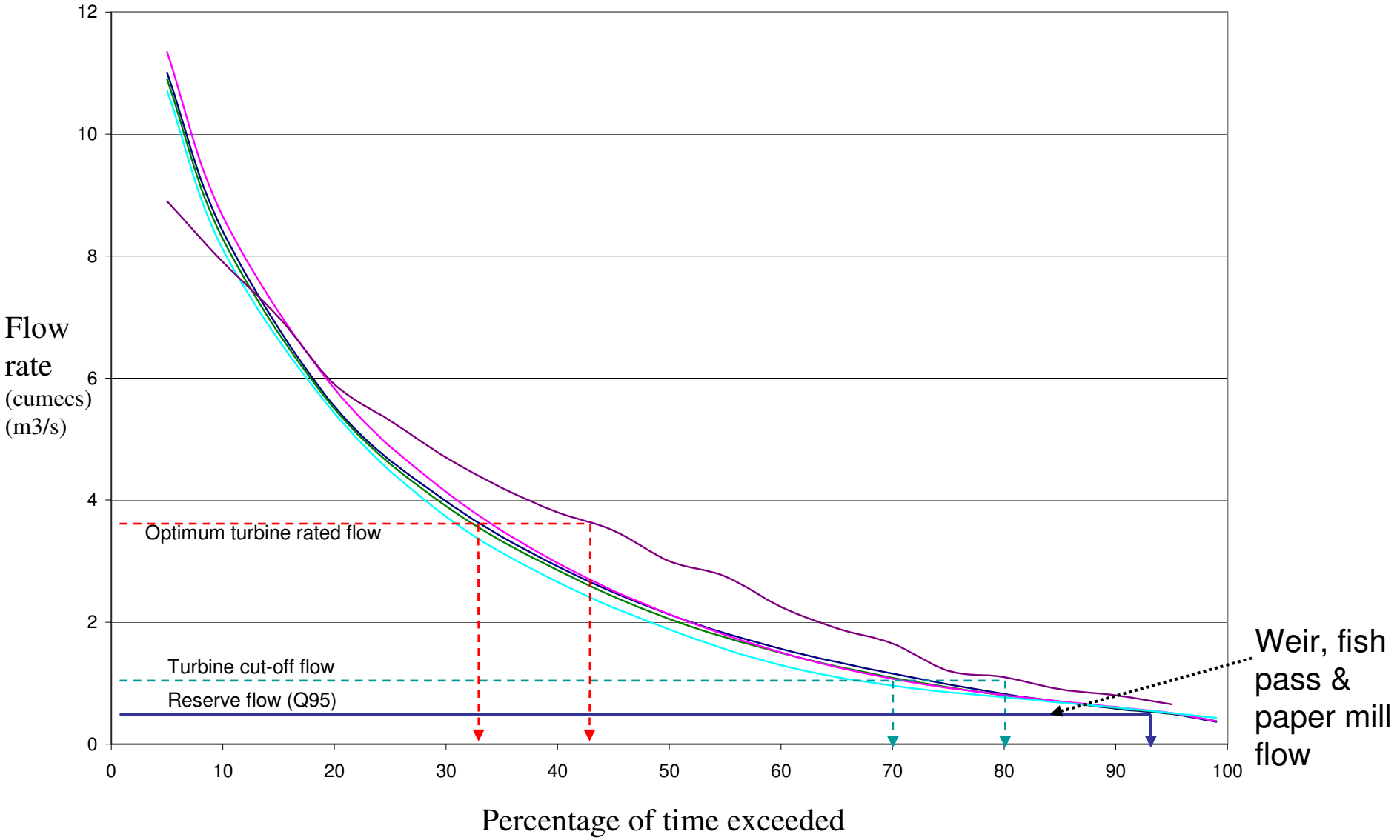
- Basin area: 129.62 km²
- Rainfall (average annual): 1289 mm
- Potential evaporation (average annual): 523 mm
- Runoff (average annual): 852 mm
- Base-Flow Index: 0.53

	Mean Flow (m^3/s)	Q95 (m^3/s)
Annual	3.502	0.473
Jan	5.924	1.246
Feb	4.767	1.036
Mar	4.475	1.008
Apr	2.630	0.788
May	1.591	0.477
Jun	1.112	0.375
Jul	1.256	0.343
Aug	1.896	0.371
Sep	2.633	0.409
Oct	4.135	0.631
Nov	5.591	0.916
Dec	6.015	1.157

River Bela flow duration curves



Flow duration curves for River Bela



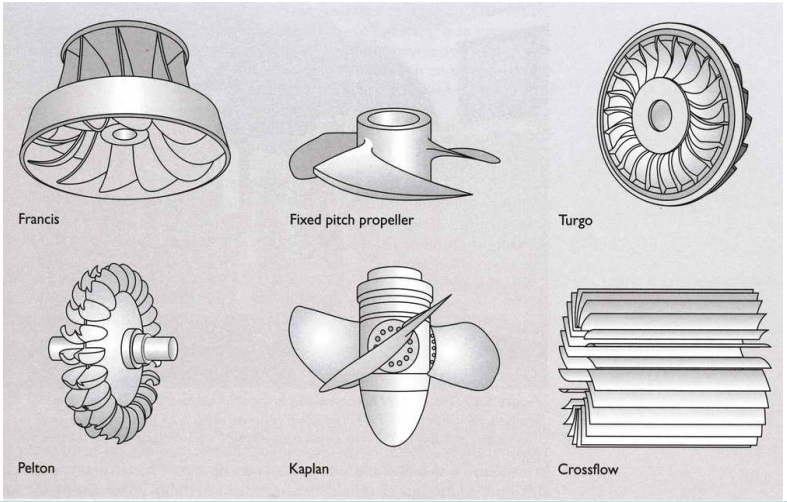
Hydro turbines

A ***turbine converts the energy in falling water into shaft power***. There are various types of turbine which can be categorised in one of several ways. The choice of turbine will depend mainly on the ***pressure head*** available and the ***design flow*** for the proposed hydropower installation. Turbines are broadly divided into three groups; ***high***, ***medium*** and ***low head***, and into two categories: ***impulse*** and ***reaction***.

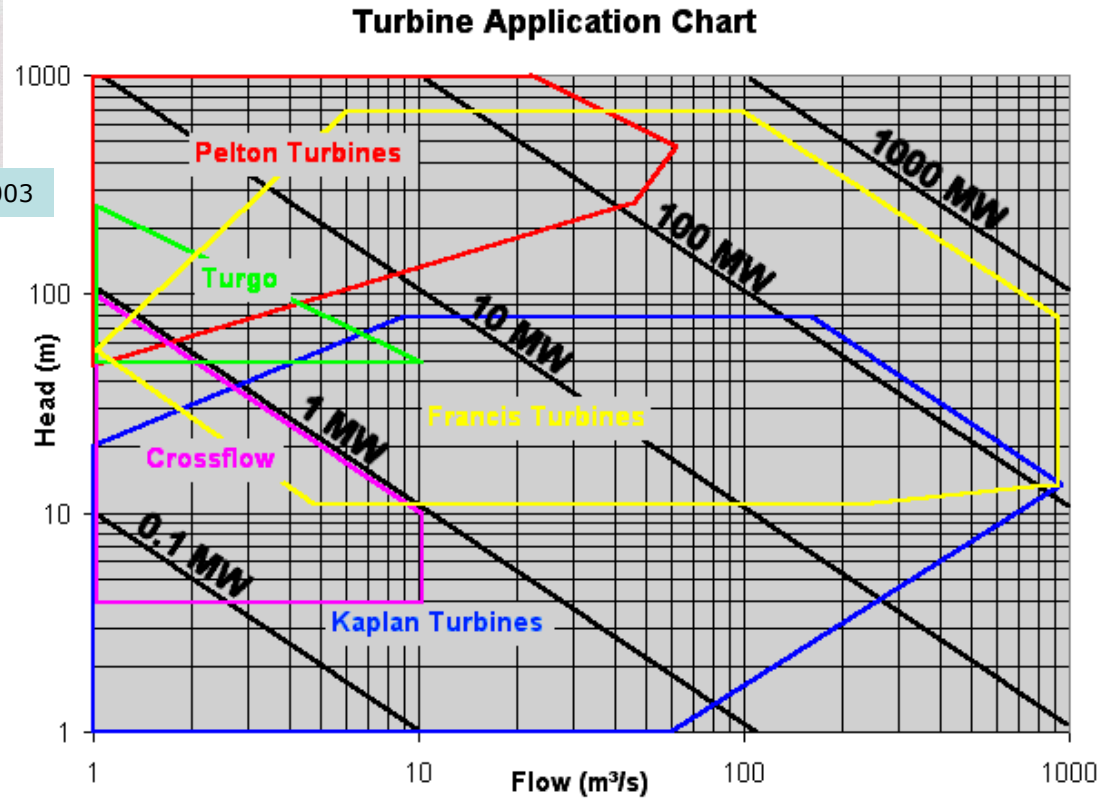
The ***difference between impulse and reaction turbines*** is ***impulse*** turbines convert the kinetic energy of a jet of water in air into movement by striking turbine buckets or blades - there is no pressure reduction as the water pressure is atmospheric on both sides of the impeller. The blades of a ***reaction*** turbine, on the other hand, are totally immersed in the flow of water, and the angular as well as linear momentum of the water is converted into shaft power - the pressure of water leaving the runner is reduced to atmospheric or lower.

	High	Medium	Low
Impulse	Pelton Turgo Multi-jet Pelton	Crossflow Turgo Multi-jet Pelton	Crossflow
Reaction		Francis Pump-as-Turbine	Propeller Kaplan

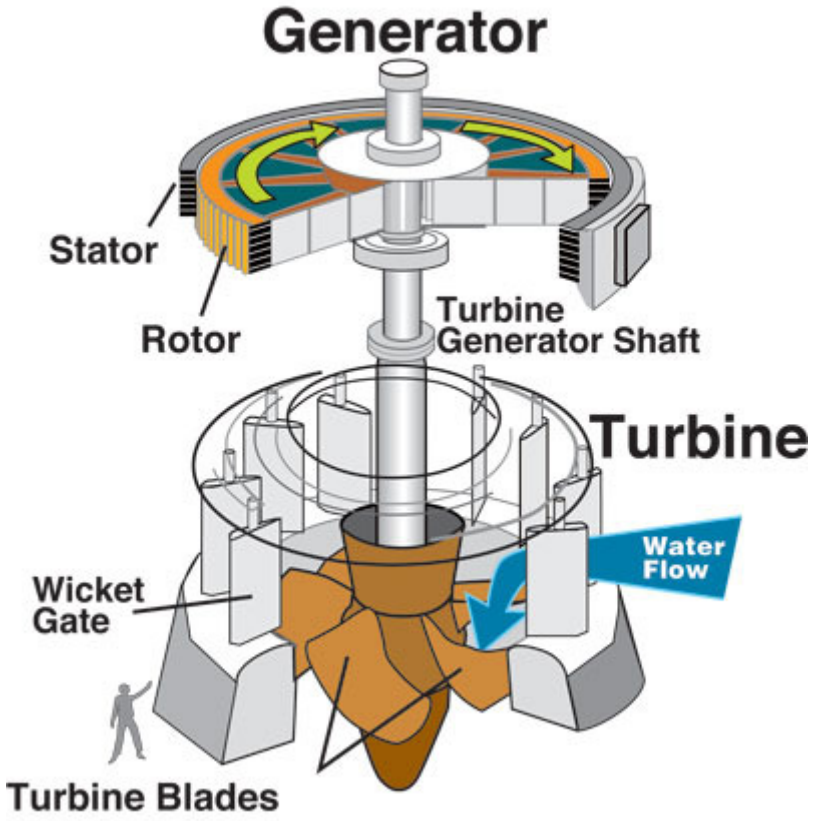
Turbine Types & Application Ranges



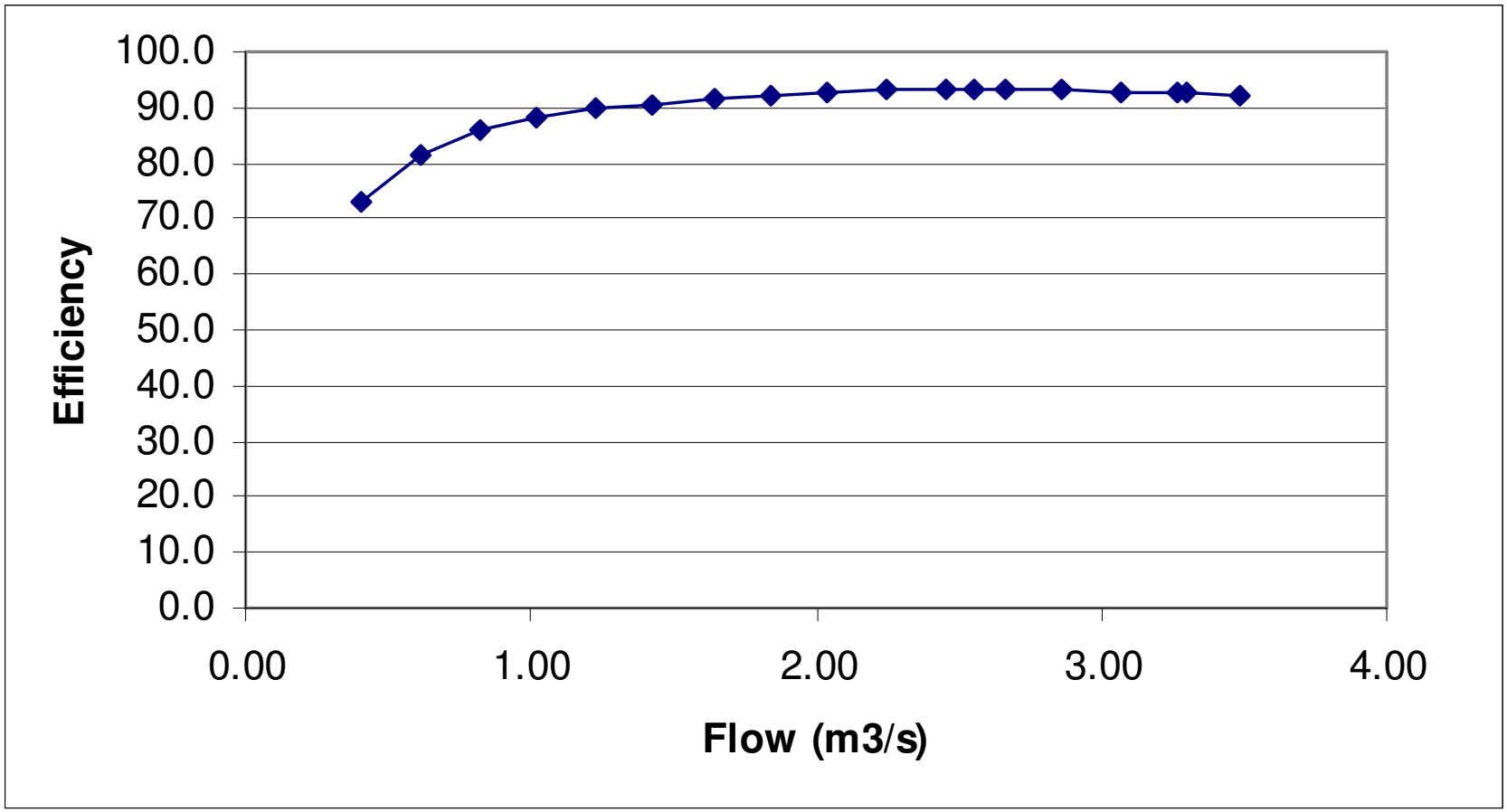
Boyle, *Renewable Energy,* 2nd edition, Oxford University Press, 2003



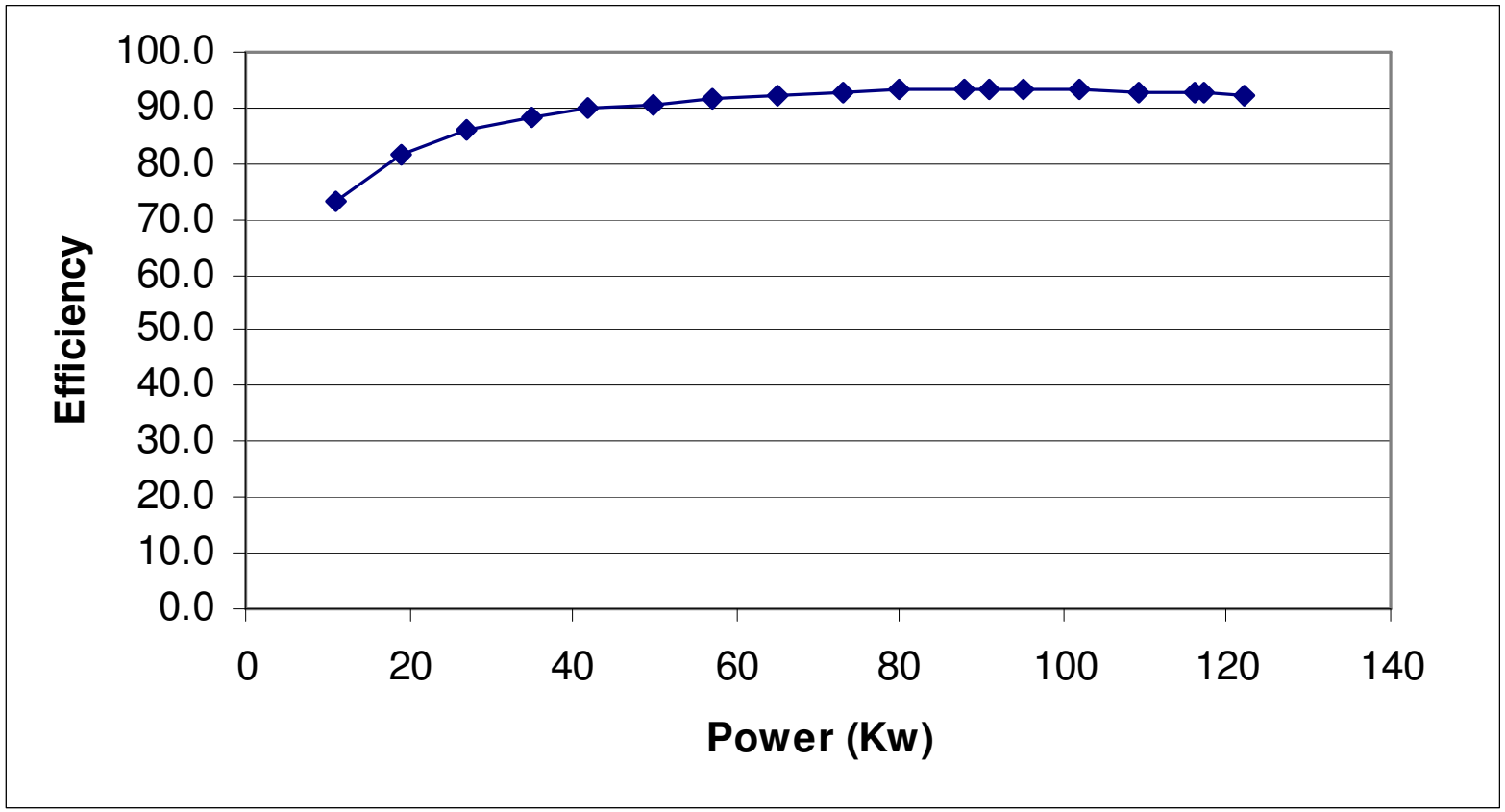
Kaplan Turbine Schematic



Kaplan Efficiency vs Discharge Curve



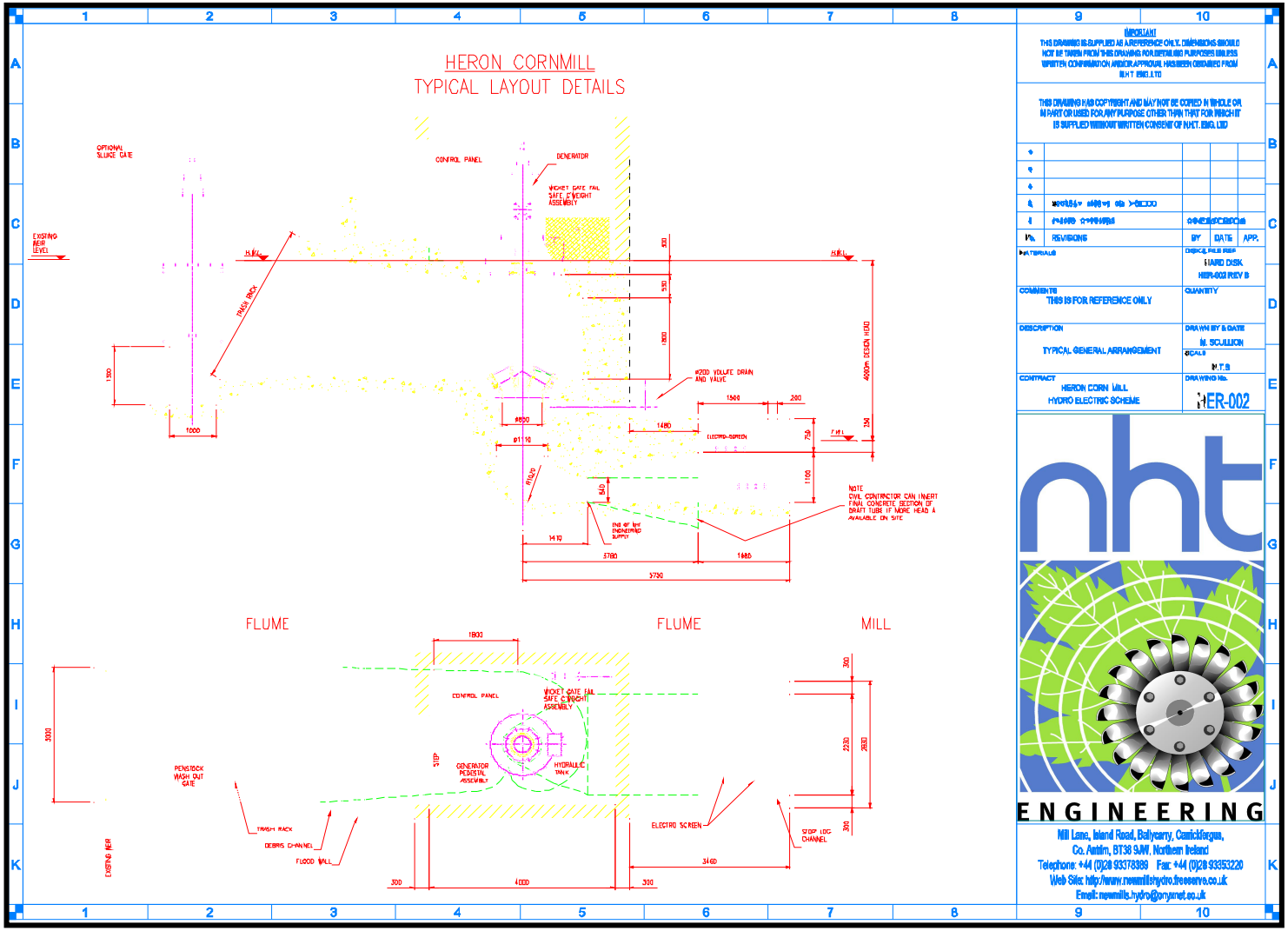
Kaplan Efficiency vs Power Curve



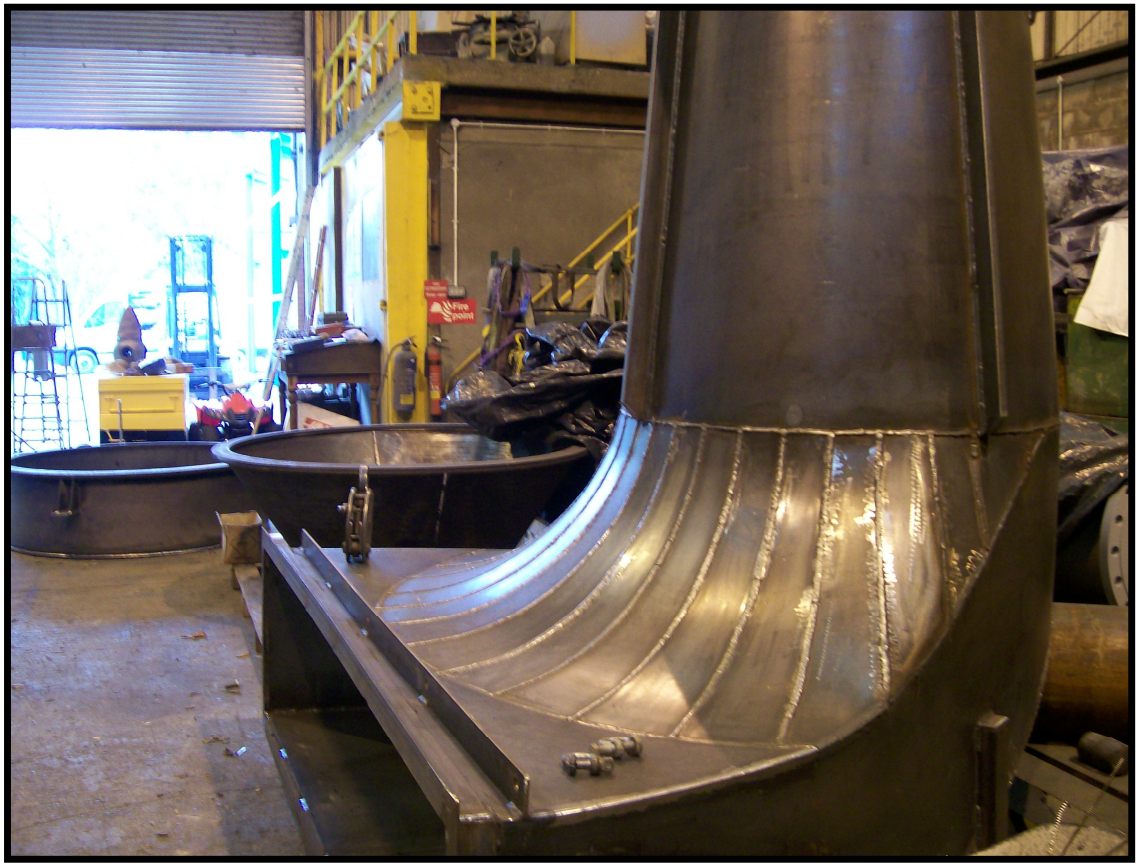
Kaplan Turbine

- Very high efficiency
- Optimise efficiency with guide vanes
- No gearbox – save up to 3% efficiency
- Reduced pollution risk
- Control at heart of turbine (maximises head even at low flows)
- Gate control at weir allows full isolation for maintenance and repair
- Electro Screen in tailrace – deters fish from area

Heron Corn Mill - Turbine details



Kaplan Turbine for Heron Corn Mill



Draft Tube

Kaplan Turbine – North Scotland

Kaplan Turbine

75kw

5m head

Stand alone device

4km from estate + houses

Generating and transmitting at 415v rated up to 11kv

Additional Barriers

- Grid Connection to Billerud Paper Mill
  - Cost
  - Obstructions
  - Discussions
  - Show stopper
- Civil works
  - Costs/estimates
  - Alterations (plans)
  - Fish pass (EA)
  - Timeline's

Backbarrow Hydro Scheme

Case Study: Heron Corn Mill, Beetham, Cumbria

Flow over the Weir at Heron Corn Mill

Terry McGuire - NHT

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