



INTER HYDRO TECHNOLOGY

A DIVISION OF R.G. PARKINS & PARTNERS LTD

PLANNING A HYDRO PROJECT IN A NATIONAL PARK

ROBERT G PARKINS

C Eng MICE



INTER HYDRO TECHNOLOGY

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FOUR STAGES ARE CONSIDERED IN THE BUILDING OF A HYDRO PROJECT

- **PRELIMINARY STUDIES**
- **SCHEME DEVELOPMENT & PERMISSIONS**
 - **DETAIL DESIGN & TENDER**
- **CONSTRUCTION AND COMMISSIONING**



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**THIS PRESENTATION CONSIDERS
A MEDIUM HEAD SMALL HYDRO
PROJECT IN SCOTLAND
UP TO STAGE TWO – PLANNING
WITH SOME EXAMPLES FROM A LOCAL
PROJECT IN THE LAKE DISTRICT
NATIONAL PARK**



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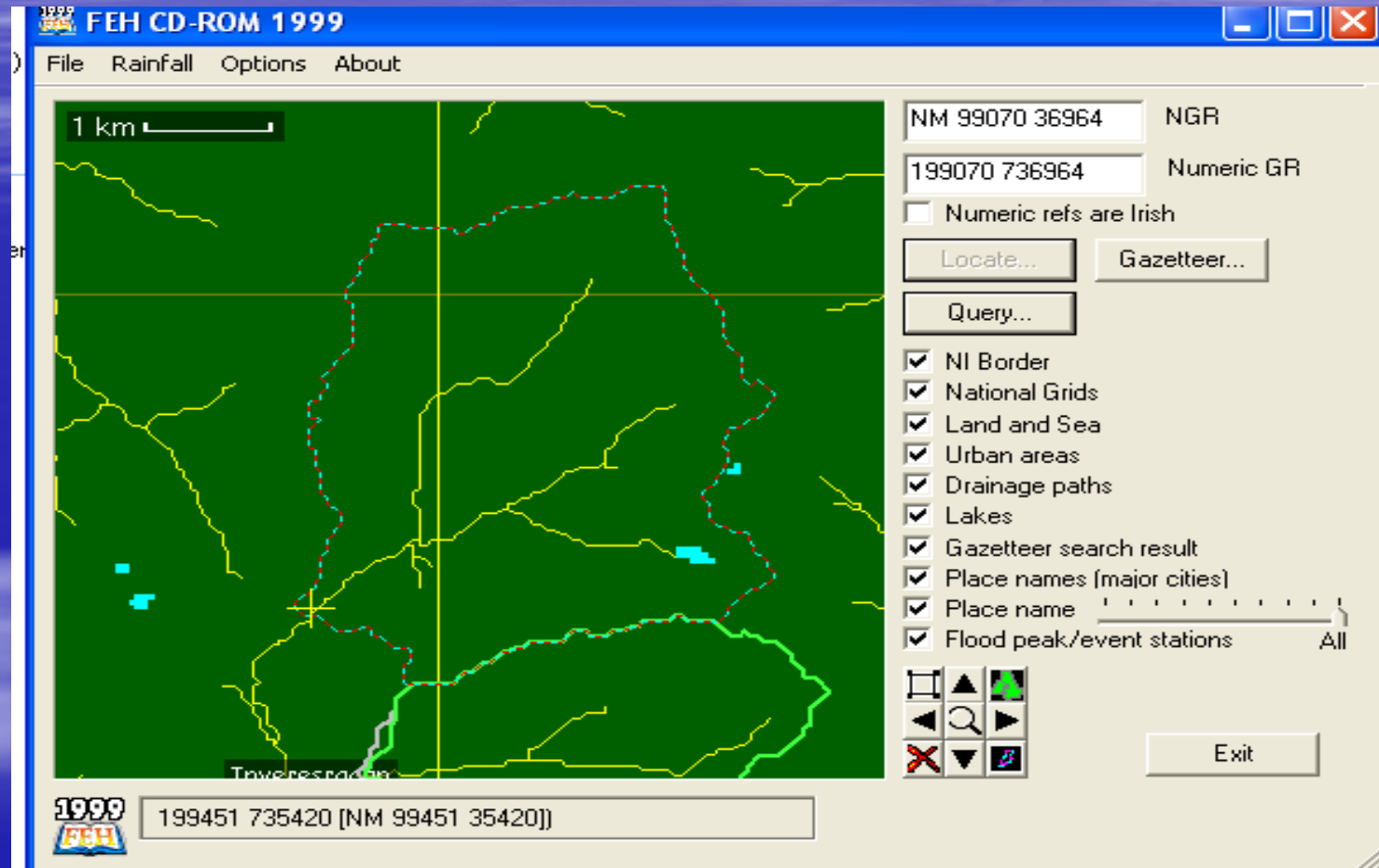
**Assuming a potential project has been identified
These are the headings for the
PRELIMINARY STUDIES:**

- **STUDY MAPS & VISIT SITE**
- **DEFINE CATCHMENT (FEH DATABASE) ***
- **DETERMINE LIKELY OPERATING HEAD**
- **RUN HYDRA MODEL**
- **FROM FLOW/DURATION CURVE MANIPULATE FLOW OPTIONS***
- **ESTIMATE DIAMETER OF PENSTOCK ***
- **OBTAIN BUDGET COST FOR TURBINE/GENERATOR**
- **ESTIMATE PROJECT COST**



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Flow Regime Report Esragan1

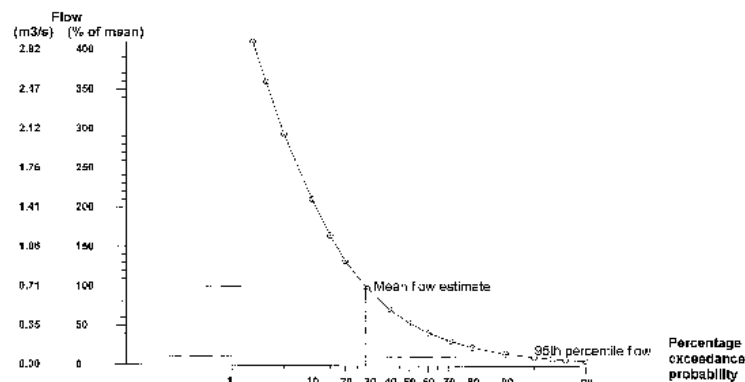
Run date / time: 26 March 2008 at 14:02
Catchment Characteristics file: c:\progra~1\hydra\data\esrag.ocf

Catchment Characteristics

Total area: 13.2 km²
Rainfall (average annual): 2070.3 mm
Potential evaporation (average annual): 831.7 mm

Flow Regime Results

Q95 (% of mean): 11.3 %
Mean flow estimate: 0.71 m³/s
Q95 (absolute): 0.08 m³/s



Power Potential Report Esragan1

Run Date / Time: 26 March 2008 at 14:02
Power Results file: c:\progra~1\hydra\data\esrag.ppr
Flow Results file: c:\progra~1\hydra\data\esrag.fr

Mean flow estimate: 0.71 m³/s
Provisional rated flow: 1.30 m³/s
Residual flow: 0.11 m³/s
Rated flow: 1.19 m³/s
Gross head: 83.50 m
Rated nett head: 86.96 m

Applicable Turbines

Marginally-applicable turbines indicated by '(mgnl)'

Francis Spiral Case

Gross average annual output: 2155.5 MWh
Nett average annual output: 2047.7 MWh
Maximum power: 931.8 kW
Rated capacity: 894.6 kW
Minimum flow: 0.5 m³/s

Turgo

Gross average annual output: 2438.2 MWh
Nett average annual output: 2318.3 MWh
Maximum power: 878.1 kW
Rated capacity: 842.9 kW
Minimum flow: 0.2 m³/s

Crossflow

Gross average annual output: 2220.7 MWh
Nett average annual output: 2109.6 MWh
Maximum power: 812.1 kW
Rated capacity: 760.1 kW
Minimum flow: 0.3 m³/s



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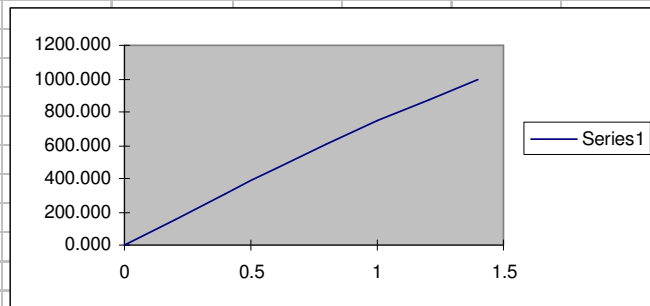
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Flow	Velocity	Reynolds Number	Friction f	Fric. Head Loss (m)	Other Losses (m)	Total Losses (m)	Available Head (m)	Power Available (kW)
0	0.000	0.00E+00	#DIV/0!			#VALUE!	#VALUE!	#VALUE!
0.2	0.398	2.79E+05	0.0036	0.197	0.007	0.204	93.296	155.589
0.4	0.796	5.58E+05	0.0033	0.708	0.029	0.737	92.763	309.401
0.6	1.194	8.38E+05	0.0031	1.515	0.065	1.581	91.919	459.882
0.8	1.592	1.12E+06	0.0030	2.613	0.116	2.729	90.771	605.515
1	1.989	1.40E+06	0.0029	3.999	0.182	4.181	89.319	744.788
1.2	2.387	1.68E+06	0.0029	5.673	0.261	5.935	87.565	876.194
1.4	2.785	1.95E+06	0.0029	7.635	0.356	7.991	85.509	998.227





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- **INPUT ALL INFORMATION INTO SPREADSHEET TO DETERMINE BEST RETURNS ***
- **PRELIMINARY DISCUSSIONS WITH E A or SEPA, E N or SNH PLANNING OFFICERS AND POWER COMPANY**
- **PREPARE OUTLINE SCHEME DRAWING AND REPORT ***



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ESRAGAN HYDRO SCHEME		APPENDIX C / 1				
H22041						
ESTIMATE OF PAYBACK PERIODS FOR MAIN CATCHMENT						
BASED ON 6p PER UNIT						
Design Flow		0.8	1.0	1.2	1.4	1.6
Gross head		86.0	86.0	86.0	86.0	86.0
600 pipe dia						
head loss		11.6	17.2	24.5	33.1	43.0
net head		74.4	68.8	61.5	52.9	43.0
% of gross head		86.5	80.0	71.5	61.5	50.0
av annual power output (MWh)		1603.0	1656.0	1587.0	1431.0	1011.0
rated capacity		412	491	537	545	540
an rev @ 6p		96180	99360	95220	85860	60660
civils costs		354000	354000	367000	359000	361000
m & e + transmission		650000	678000	701000	744000	799000
fees		100400	103200	106800	110300	116000
project cost		1104400	1135200	1174800	1213300	1276000
payback period		11.48	11.43	12.34	14.13	21.04
700 pipe dia						
head loss		5.2	8.0	11.3	15.3	19.8
net head		80.8	78.1	74.7	70.7	66.2
% of gross head		94.0	90.8	86.9	82.2	77.0
av annual power output (MWh)		1744	1880	1932	1921	1854
rated capacity		448	558	654	732	791
an rev @ 6p		104640	112800	115920	115260	111240
civils costs		381000	381000	385500	390000	394500
m & e + transmission		650000	678000	701000	744000	799000
fees		103100	105900	108650	113400	119350
project cost		1134100	1164900	1195150	1247400	1312850
payback period		10.84	10.33	10.31	10.82	11.80
800 pipe dia						
head loss		2.7	4.2	5.9	8.0	10.4
net head		83.3	81.8	80.1	78.0	75.6
% of gross head		96.8	95.1	93.1	90.7	87.9
av annual power output (MWh)		1820	1997	2100	2150	2150
rated capacity		468	593	711	819	917
an rev @ 6p		109200	119820	126000	129000	129000
civils costs		424000	424000	428000	433000	437000
m & e + transmission		650000	678000	701000	744000	799000
fees		107400	110200	112900	117700	123600
project cost		1181400	1212200	1241900	1294700	1359600
payback period		10.82	10.12	9.86	10.04	10.54



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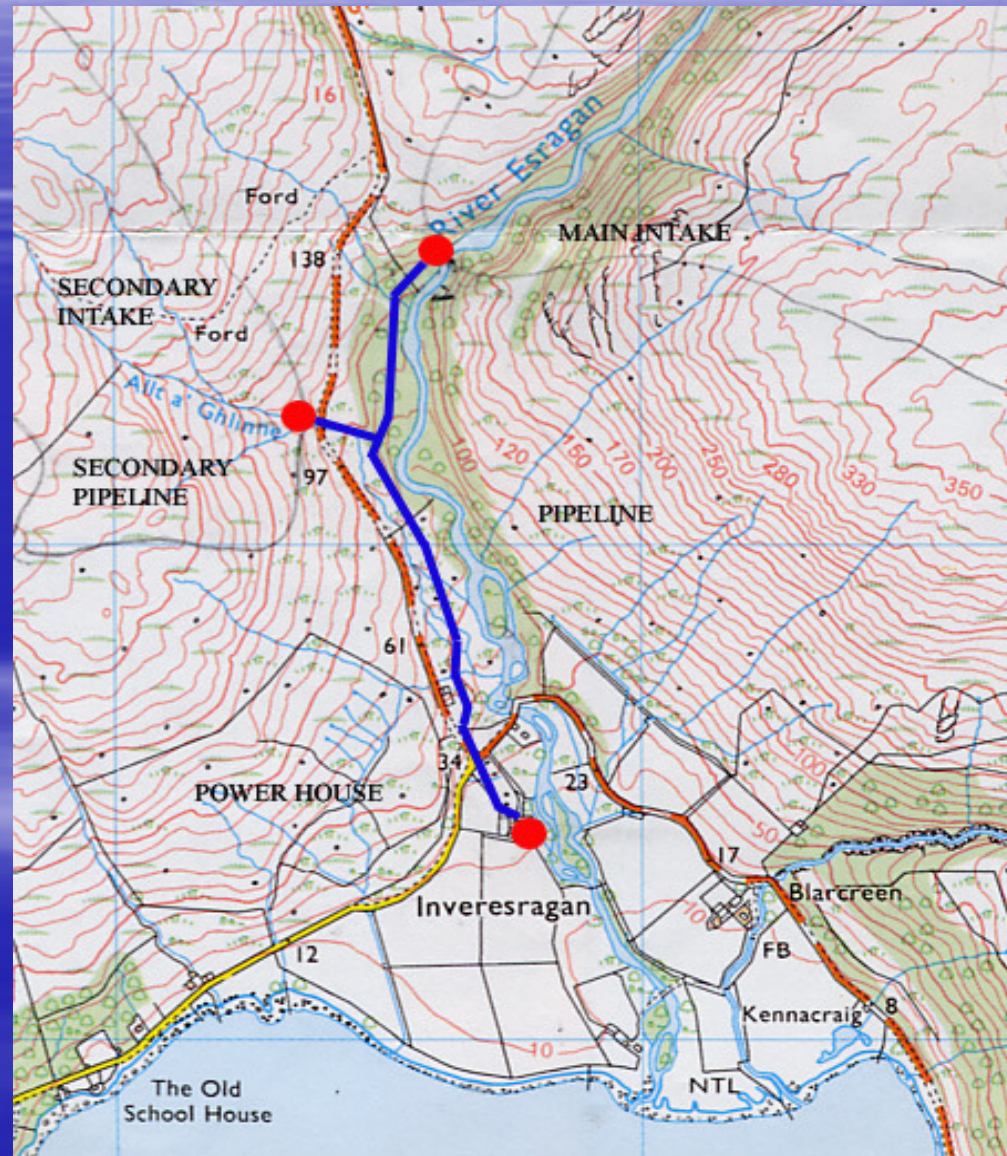
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SCHEME DEVELOPMENT AND PERMISSIONS

- **COMMISSION TOPOGRAPHICAL SURVEY**
- **COMMISSION CDM-C**
- **OPEN NEGOTIATIONS WITH EA or SEPA and ENVIRONMENTAL INTERESTS**

- **SET-UP FLOW MONITORING (assuming ungauged catchment)**
- **RUN 'LOW FLOWS' COMPUTER MODEL ***
- **CONSIDER FURTHER POWER PRODUCTION OPTIONS ***
- **SCOPE ENVIRONMENTAL STUDIES & APPOINT SPECIALISTS**



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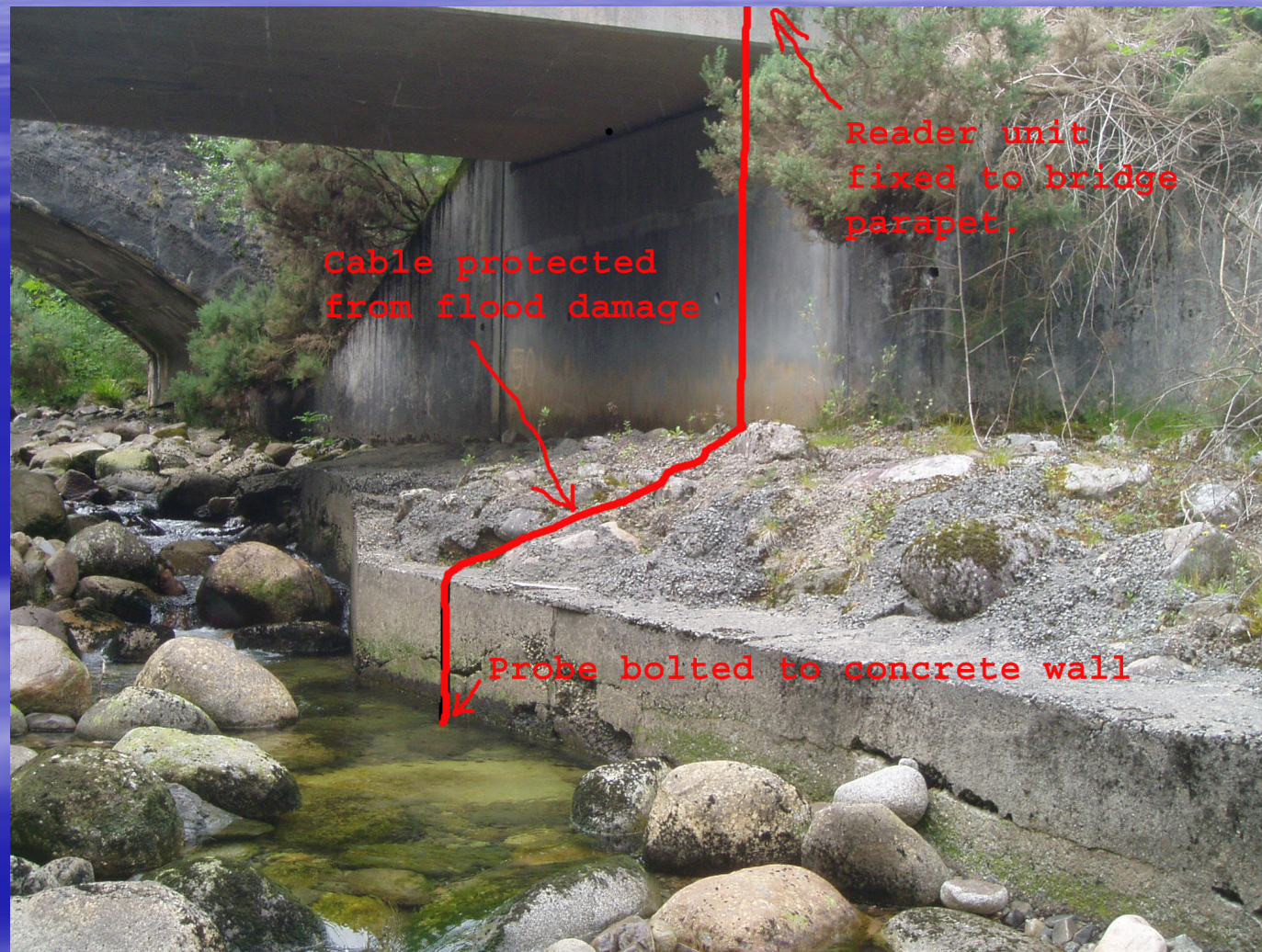
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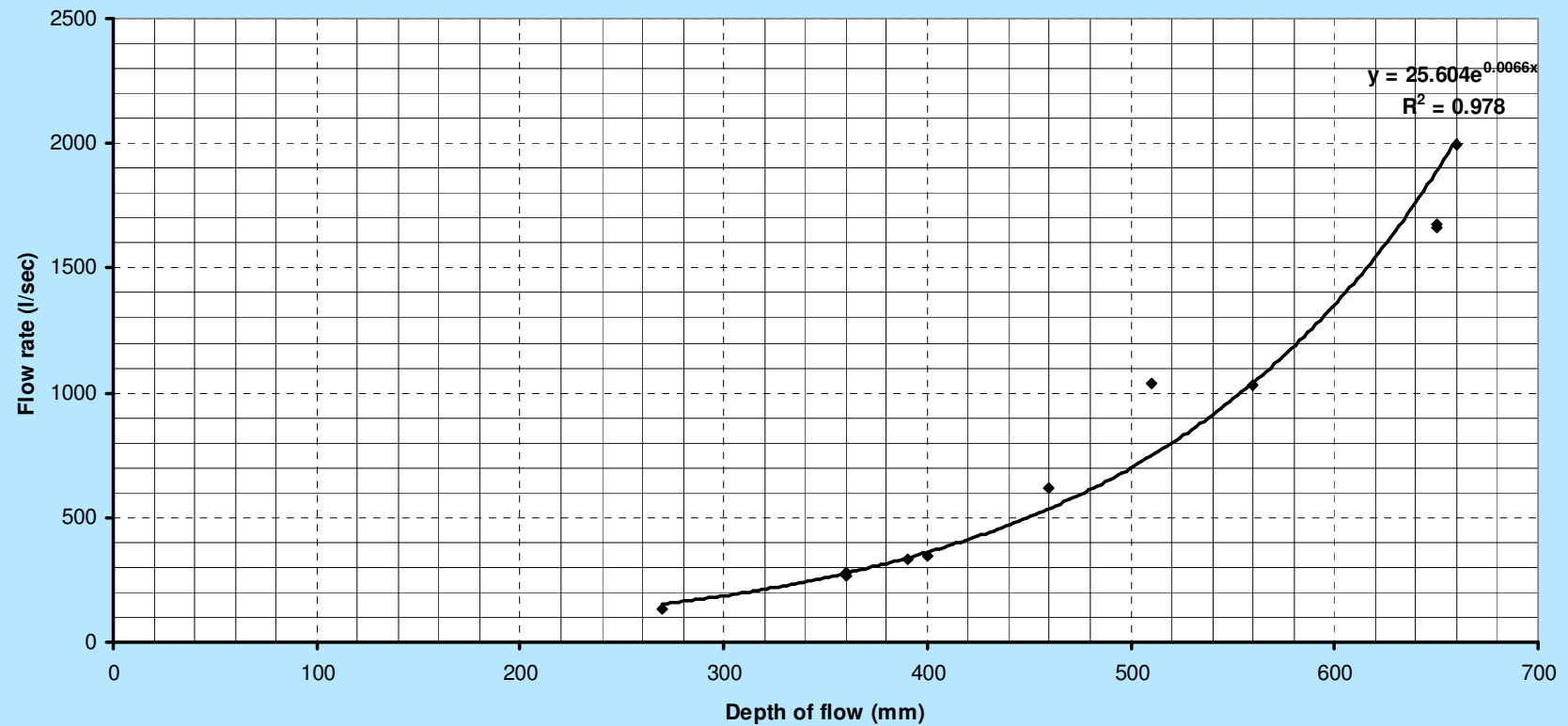




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Figure 5: Relationship calculated between measured river flow and depth.





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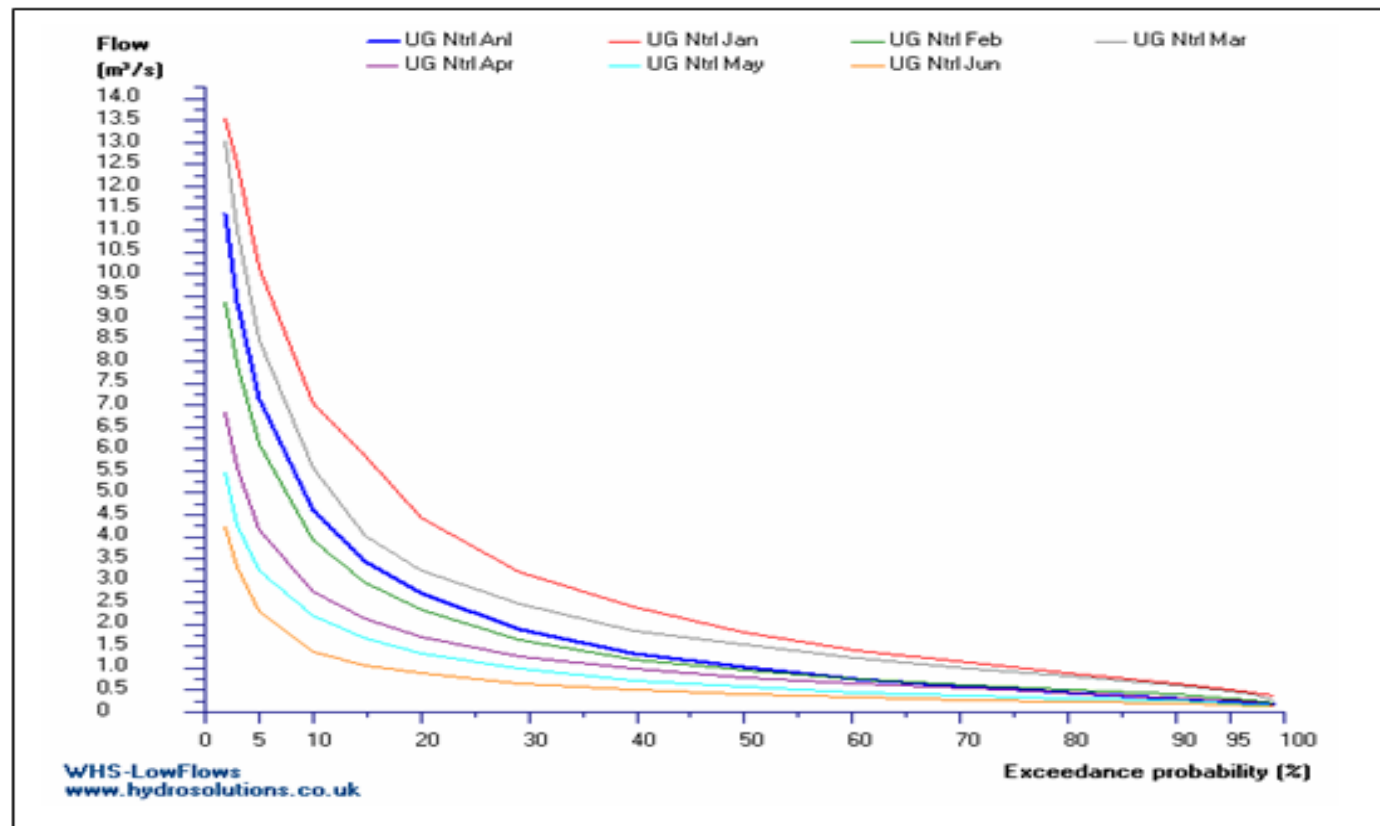


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Monthly Flow Duration Curves

January-June



July-December



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	A	B	C	D	E	F	G	H	I	J	K	L	M
21	Table B.1 Power and energy output from compensation flow scenario 1												
22	River flow %age exceedence	River flow Q (m3/s)	Comp'n flow (m3/s)	Available flow (m3/s)	Flow to turbine (m3/s)	Flow to turbine as %age of design flow %	Net head m	Efficiency %	Power output (kW)	x-unit %age	y-unit (kW)	Gross energy kWh/year	Net energy kWh/year
23													
24	5%	2.15	0.15	2.00	2.00	25	30.00	80.0	471	0.085			
25	10%	2.15	0.15	2.00	2.00	25	30.00	80.0	471	0.085	471	350617	343605
26	15%	2.15	0.15	2.00	2.00	25	30.00	80.0	471	0.085	471	350617	343605
27	20%	2.15	0.15	2.00	2.00	25	30.00	80.0	471	0.085	471	350617	343605
28	25%	1.90	0.15	1.75	1.75	22	32.20	80.0	442	0.085	457	339953	333154
29	30%	1.60	0.15	1.45	1.45	18	34.20	85.0	414	0.085	428	318592	312221
30	35%	1.40	0.15	1.25	1.25	16	35.90	87.0	383	0.085	398	296537	290607
31	40%	1.14	0.15	0.99	0.99	12	37.30	89.0	322	0.085	353	262621	257368
32	45%	0.90	0.15	0.75	0.75	9	38.40	90.0	254	0.085	288	214698	210404
33	50%	0.80	0.15	0.65	0.65	8	38.70	90.0	222	0.085	238	177352	173805
34	55%	0.70	0.15	0.55	0.55	7	39.10	90.0	190	0.085	206	153373	150306
35	60%	0.57	0.15	0.42	0.42	5	39.30	90.0	146	0.085	168	124944	122445
36	65%	0.50	0.15	0.35	0.35	4	39.50	90.0	122	0.085	134	99699	97705
37	70%	0.40	0.15	0.25	0.25	3	39.80	90.0	88	0.085	105	78149	76586
38	75%	0.33	0.15	0.18	0.18	2	39.80	90.0	63	0.085	76	56254	55129
39	80%	0.27	0.15	0.12	0.00	0	0.00	90.0	0	0.085	32	23548	23077
40	85%	0.23	0.15	0.08	0.00	0	0.00	90.0	0	0.085	0	0	0
41	90%	0.15	0.15	0.00	0.00	0	0.00	90.0	0	0.085	0	0	0
42	95%	0.15	0.15	0.00	0.00	0	0.00	90.0	0	0.085	0	0	0
43	100%	0.15	0.15	0.00	0.00	0	0.00	90.0	0	0.085	0	0	0
44							Max power (kW)		471	Total energy		3197573	3133621
45										kWh/year			



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- **PREPARE SCHEME DESIGN DRAWINGS SUFFICIENT FOR PLANNING SUBMISSION**

SCHEME LAYOUT

WEIR & INTAKE (inc. fish pass if required) **

PENSTOCK SELECTION **

POWERHOUSE & TAILRACE *

TEMPORARY ACCESS TRACKS

- **CARRY OUT SITE INVESTIGATION**

- **REVISIT COST PLAN**

- **PREPARE & SUBMIT APPLICATIONS FOR IMPOUNDMENT, ABSTRACTION & LAND DRAINAGE LICENSES (method stats)**

- **APPLY FOR GRID CONNECTION**

- **APPLY FOR PLANNING PERMISSION**

- **WAIT FOR DECISIONS! ***



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PENSTOCK SELECTION 20 21

POWERHOUSE & TAILRACE 23

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