



Stream Flow Monitoring to Support Watershed Assessment in Bolivia, Ecuador, and Zambia

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Conrad Heatwole - Virginia Tech, Blacksburg, Va. USA
Mirco Peñaranda - UMSA, La Paz, Bolivia
Ana Karina Saavedra - PROMIC, Cochabamba, Bolivia
Carlos Montúfar - SIGAGRO / INIAP, Quito, Ecuador
White Lunga - WCS/COMACO, Lundazi, Zambia



Background

- Why measure stream flow?
 - Water balance/water availability studies
 - Volume and peak flow for hydraulic design
 - Estimate loads (mass) of constituents
 - sediment, nutrients, chemicals
- Applications
 - Water supply allocation (irrigation, etc.)
 - Hydraulic design
 - Support modeling for extrapolation studies
 - Quantify conditions for assessing PES

Rapid hydrologic assessment

- *Basic question ...* is a low-cost, rapid assessment of stream flow feasible
 - Found one study that attempted a “rapid hydrologic assessment” in regards to PES – one location, no follow up reports, so don’t know the outcome
 - Multiple countries and sites will substantiate insights, conclusions, and recommended practices

An example of the alternative...

'Permanent' installations
- take time to implement, and
- are costly to install



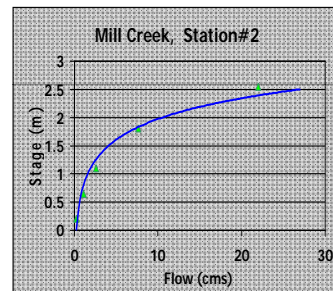
Yet, 'permanent' installations do not ensure results and long-term value



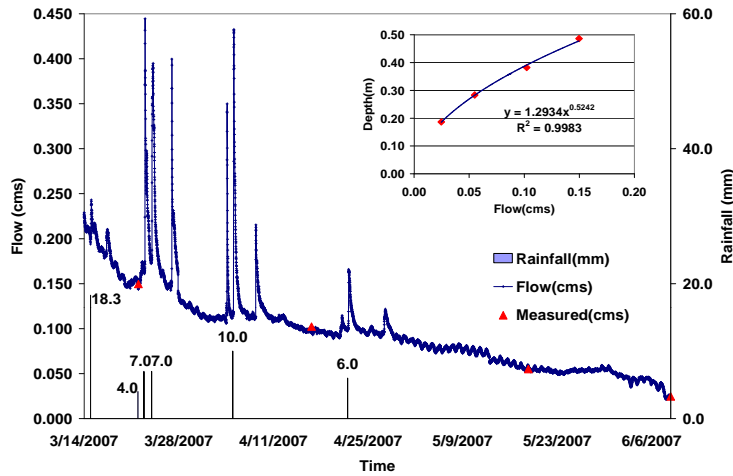


Stream Flow Measurement Basics

1. Water depth with time
 - Staff gage readings (daily)
 - Chart or sensor for continuous record
2. Depth--discharge relationship
 - Flow rate at different water depths
 - Velocity and cross-section
 - Float (orange)
 - Flow meter
 - Tracer (salt) study
3. Discharge over time
 - Product of 1) and 2)



Example: Flow rate from pressure sensor and 4 flow measurements for the Kamwamphula River, Eastern Province, Zambia



Overall approach – Stream flow

- Criteria:
 - Easy and quick to install
 - Simple and reliable
- Implementation:
 - Staff gauge for reference and 'local data'
 - Pressure sensor for depth measurement (15min)
 - Flow measurement depending on conditions:
 - Flow meter; Salinity method; Float



Weather and Rainfall

- Weather station
 - Rainfall, Temperature, Relative humidity, Wind speed and direction, Solar radiation, Barometric pressure
- Data logging rain gauges
- Manual rain gauges



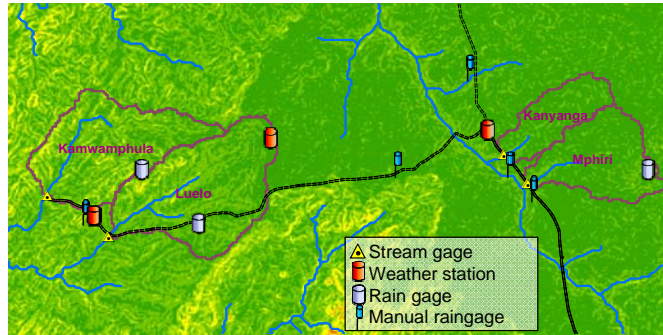
Stream site selection criteria

- General location for study objectives
- Accessibility (for researchers)
- Proximity to local observer
- Hydrologically suitable
 - Straight, stable channel
 - Even flow
 - Avoid sedimentation
 - Protected from floods
- Security



Location not hydrologically suitable

Study watersheds – Magodi



Paired watersheds (Kamwamphula, Luelo) in Hill region

- similar size, slopes and landscape position
- side-by-side,
- predominantly forested vs. cleared land use

Dambo watersheds (Kanyanga, Mphiri)

- comparison of plateau hydrology

Pressure Sensor Installation

- Stand pipe stilling well on supporting tower
- Pipe fastened to structure
 - Bridge, rock, tree
- Pipe as structure and sensor holder
- Culvert
- Sensor hidden in 'rock'

Stream stations



Experience to date...

- 5 locations – 4 countries
 - Approximately 1 week per location (follow up work needed)
 - 22 stream gauging stations (pressure sensors and staff gauge) installed
 - 8 weather stations installed and operating
 - 17 recording rain gauges (tipping bucket)
 - Initial data on flow rates at each station
 - Hands-on training !

Implementation keys...

- Collaboration with host-country partner
- Engaging community through established channels




Philippines – Alanib watershed



Community Observers - Rainfall

NO	DATE	MISSTIONS	START TIME	END TIME
1	25/11/08	1.0	08:30	10:30
2	26/11/08	2	18:00	18:45
3	28/11/08	1	06:10	06:15
4	28/11/08	0.5	14:55	15:00
5	30/11/08	3.0	06:30	10:40
6	1/11/08	3.7	02:00	05:00
7	3/11/08	4	14:45	15:00
8	3/11/08	3	18:00	22:30
9	4/11/08	4	07:30	09:00
10	6/11/08	2	07:25	10:00
11	7/11/08	1.6	19:30	03:00
12	9/11/08	1.5	23:00	23:15
13	10/11/08	3	08:40	08:50
14	12/11/08	5.5	16:00	19:04
15	12/11/08	2.5	07:30	08:00
16	12/11/08	2.7	19:30	22:00
17	15/11/08	3.5	17:40	18:30
18	16/11/08	1.5	12:10	12:30
19	18/11/08	2.0	11:00	12:31
20	19/11/08	2.5	18:40	18:47
21	20/11/08	1.6	18:00	19:05
22	23/11/08	1.4	19:30	22:00
23	24/11/08	1.6	11:00	12:08
24	25/11/08	5.5	20:10	05:00
25	26/11/08	1.45	22:00	04:30
26	28/11/08	1.2	01:30	05:00
27	29/11/08	2.9	02:20	03:30
28	30/11/08	2.5	04:30	05:25

29	3/11/08	1.2	07:30	10:00
30	11/11/08	2.5	14:30	20:30
31	21/11/08	6	16:30	17:00
32	31/11/08	5	18:30	18:40
33	5/12/08	4	18:00	18:12
34	9/12/08	7.2	23:00	01:20



Flow Rate - Stage

DATE 09-02-09	Time 13:35	STATION	DEPTH	VELOCITY
		10	32	0.58
		20	36	0.56
		30	40	0.60
		40	42	0.62
		50	49	0.68
		60	52	0.72
		70	68	0.75
		80	70	0.80
		90	75	0.88
		100	80	0.90
		110	87	0.96
		120	90	1.07
		130	95	1.15
		140	90.5	1.17
		150	89	1.20
		160	81.5	1.13
		170	78	1.07
		180	65	0.98
		190	54	0.76
		200	25	0.56

DATE 20/02/08	Time 13:09	STATION	DEPTH	VELOCITY
		10	1.3	0
		20	2.2	0.09
		30	2.7	0.26
		40	3.3-5	0.15
		50	3.7	0.15
		60	3.7-5	0.21
		70	4.1	0.24
		80	4.5	0.33
		90	4.1	0.35
		100	4.0-5	0.37
		110	4.6	0.33
		120	4.7-5	0.32
		130	4.8	0.36
		140	5.1	0.50
		150	5.2	0.32
		160	5.5-5	0.31
		170	5.2	0.31
		180	4.5	0.30

Flow measurement – Salinity method

Flow measurement using velocity meter and cross-section is not feasible in turbulent mountain streams

- Salt dilution method is being used where appropriate and materials have been translated to Spanish
- Some expertise is needed for implementation and interpretation
- Equipment is low cost, and results can be very accurate



Results to date...

- 22 stream stations
 - 1 sensor stolen (Bolivia)
 - 2 stations washed out (Ecuador)
 - 2 stations moved from original location
 - Minor issues with sediment contamination
- Weather stations
 - No known issues
- Data download and maintenance by partners (except for Zambia)
- Pleased with data from local observers

Research Outputs

- Individual site data supports modeling
- Comparative analysis
 - Hydrologic response: water balance, storage and release function, flood attenuation
 - *Impact of LU practices in plateau and hill region of Eastern Luangwa Valley on local water management and impacts on the Luangwa River flow and sedimentation*
- Cross-project synthesis

Low cost monitoring – will it work?



Thanks to dedicated partners...



... results to date are promising.

