Spatial variation of pharmaceutical concentrations in the River Almond

EU noPILLS project

- Funded by Interreg IV B
- 6 partners in 5 countries
- Aim: To reduce pharmaceutical pollution in the environment
  - Technical solutions: wastewater treatment
  - Societal solutions: reducing input of pharmaceutical residues via behaviour change
  - Increase understanding of sources and pathways

Selection of study catchment

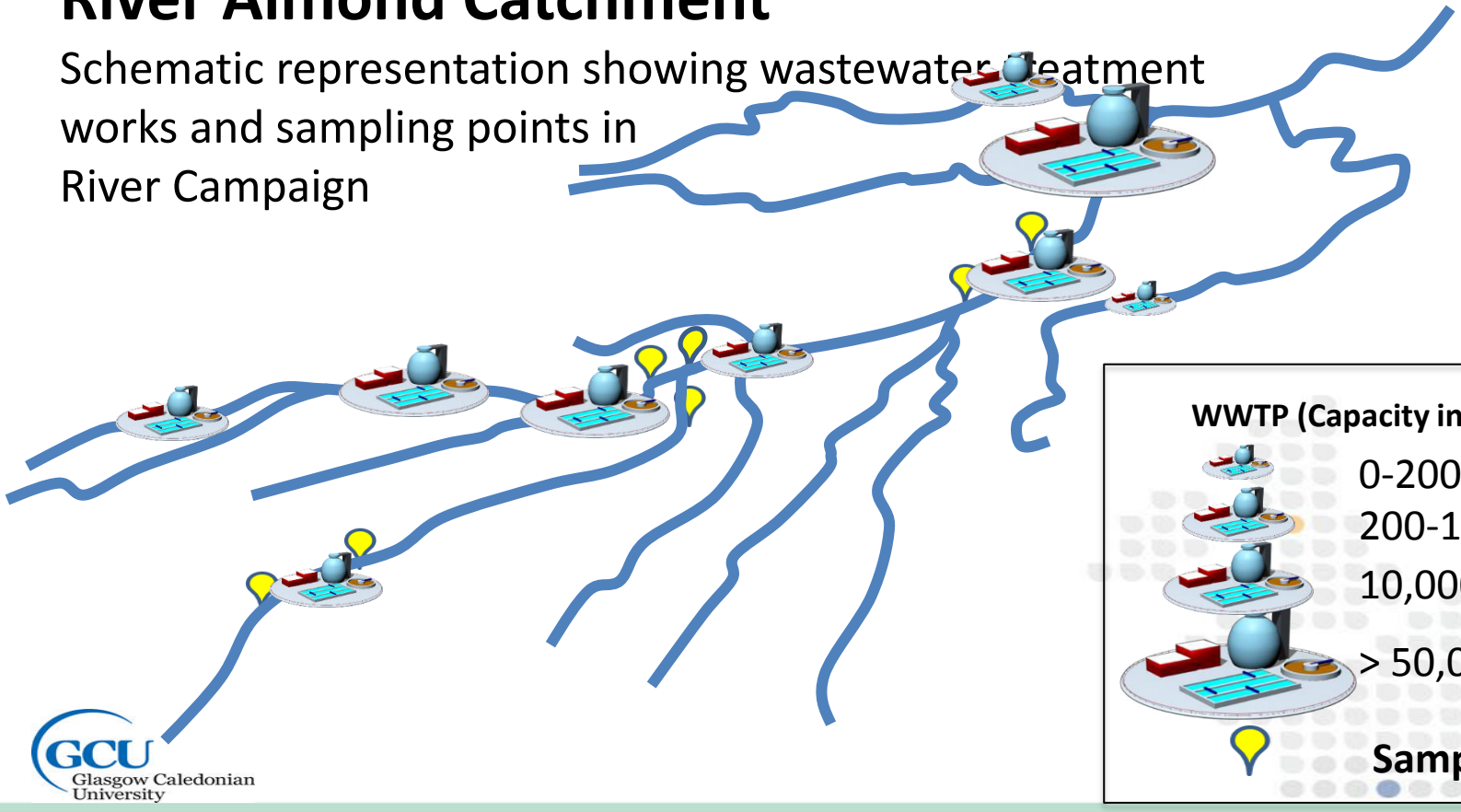
- UKWIR-CIP results for some of the STW:
  - Low environmental dilution
  - High effluent concentrations

- Catchment characteristics:
  - Highly urbanised
  - Sewer system overstretched with multiple CSOs

River Almond

River Almond Catchment

Schematic representation showing wastewater treatment works and sampling points in River Campaign



WWTP (Capacity in PE)

0-200 PE

200-10,000 PE

10,000-50,000 PE

> 50,000 PE

Sampling point

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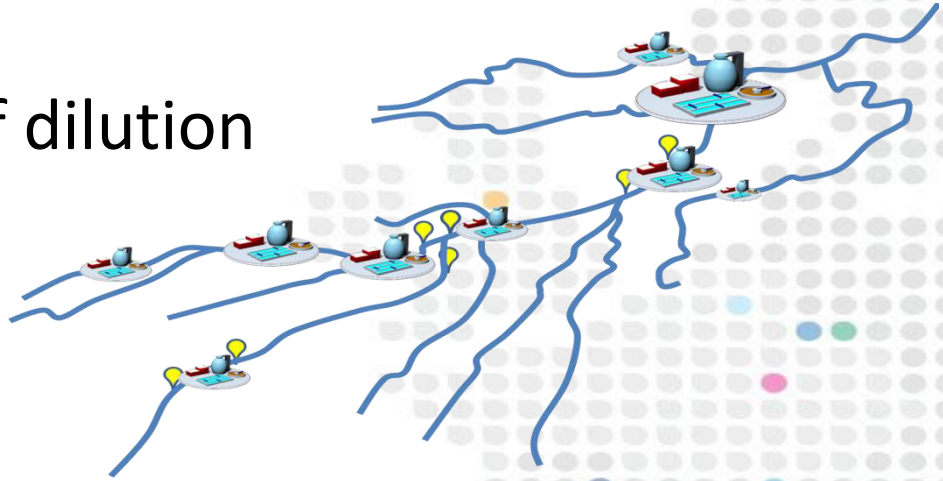
Specific objectives

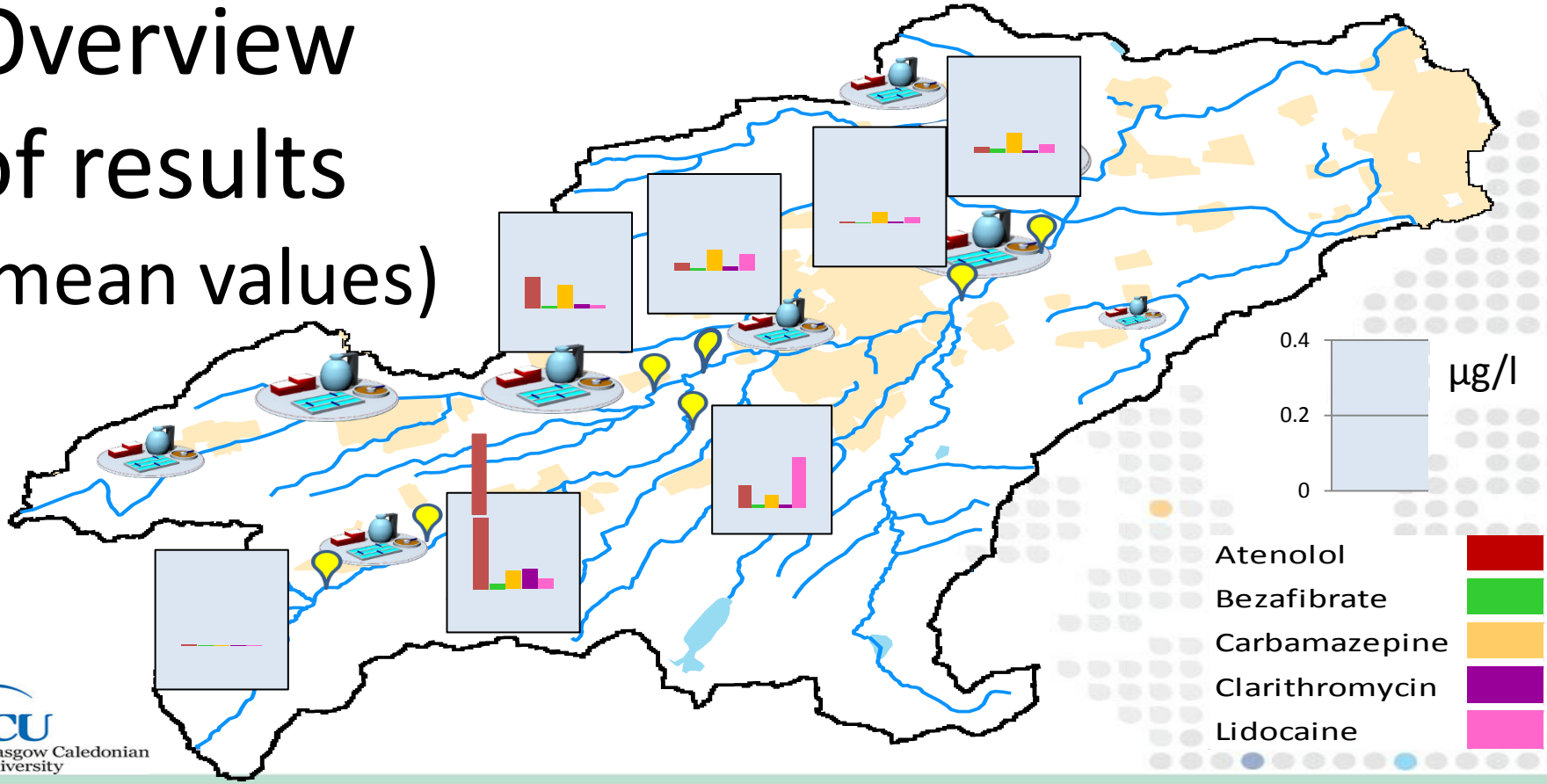
- To build up a general understanding of concentrations in the catchment
- To investigate long range (10km) transport of pharmaceutical pollutants
- To investigate the effect of dilution by a tributary
- To investigate the effect of a large WWTP



Sampling and analysis

- Sampling
  - 4 consecutive days in June 2014
  - Characterised by dry weather and low flows
  - Daily grab samples & flow measurements
  - Flow estimation via relative catchment size
- Analysis
  - LC-MS/MS (Thermo Fisher Scientific Q Exactive Quadrupole Orbitrap mass spectrometer)
  - Deuterated internal standards used where available

Overview of results (mean values)



‘Sense check’

	Expected daily load (mg/day)	Measured daily load (mg/day)
Atenolol	4404	3802
Bezafibrate	285	133
Carbamazepine	195	462
Clarithromycin	916	503
Lidocaine	-	216

- All values within a factor 3 of prediction
- Prediction based on national average prescriptions (2012-13 NHS data), excretion data and removal data from literature
- Measured data are concentrations in daily grab samples x measured flow at Loc2

Environmental risk

$$RQ = \frac{PEC}{PNEC}$$

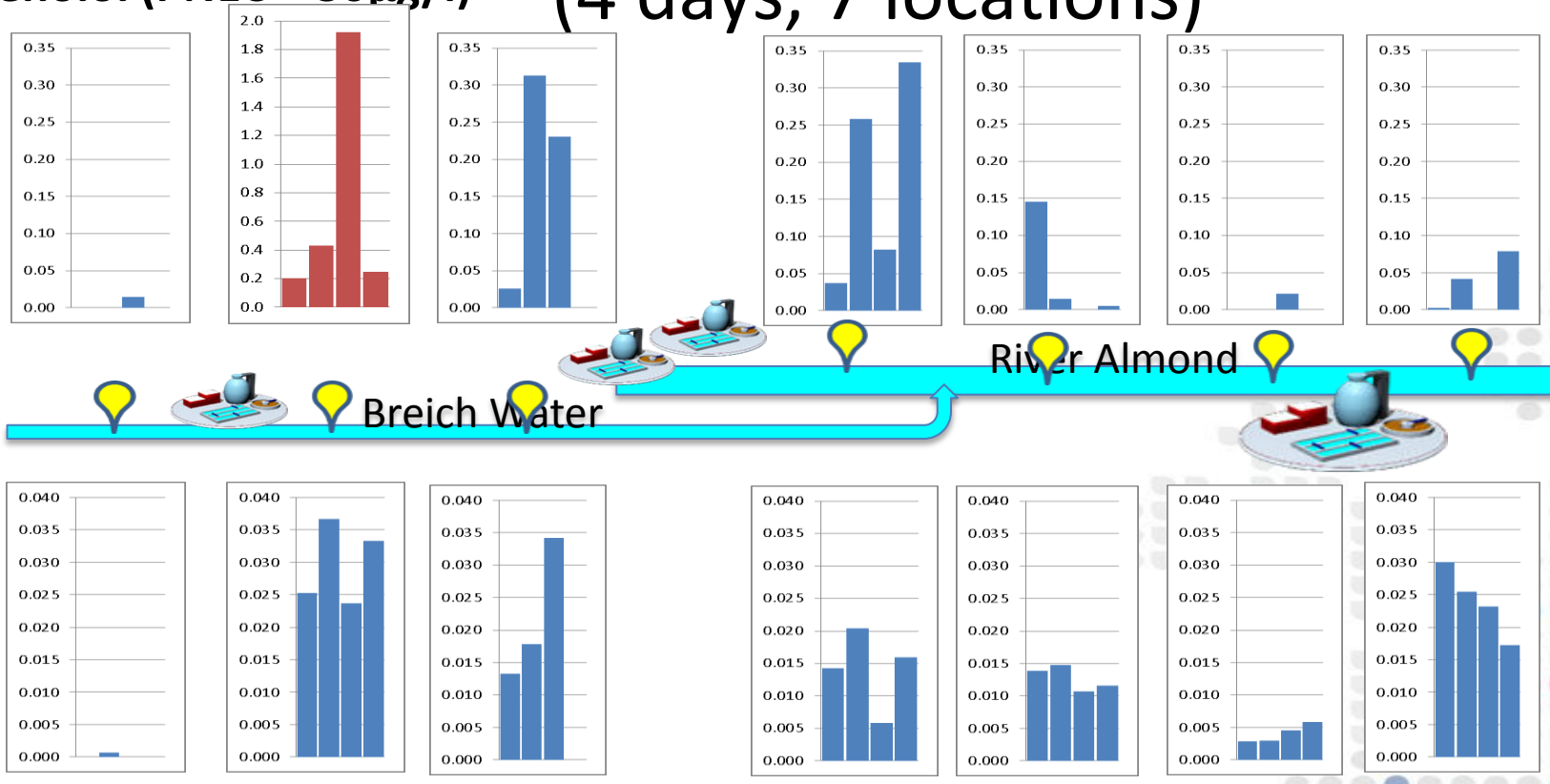
PEC = Measured environmental concentration

PNEC = Predicted no-effect concentration

High risk:	RQ > 1
Moderate risk:	1 > RQ > 0.1
Low risk:	RQ < 0.1

Spatial and Temporal Variation (4 days, 7 locations)

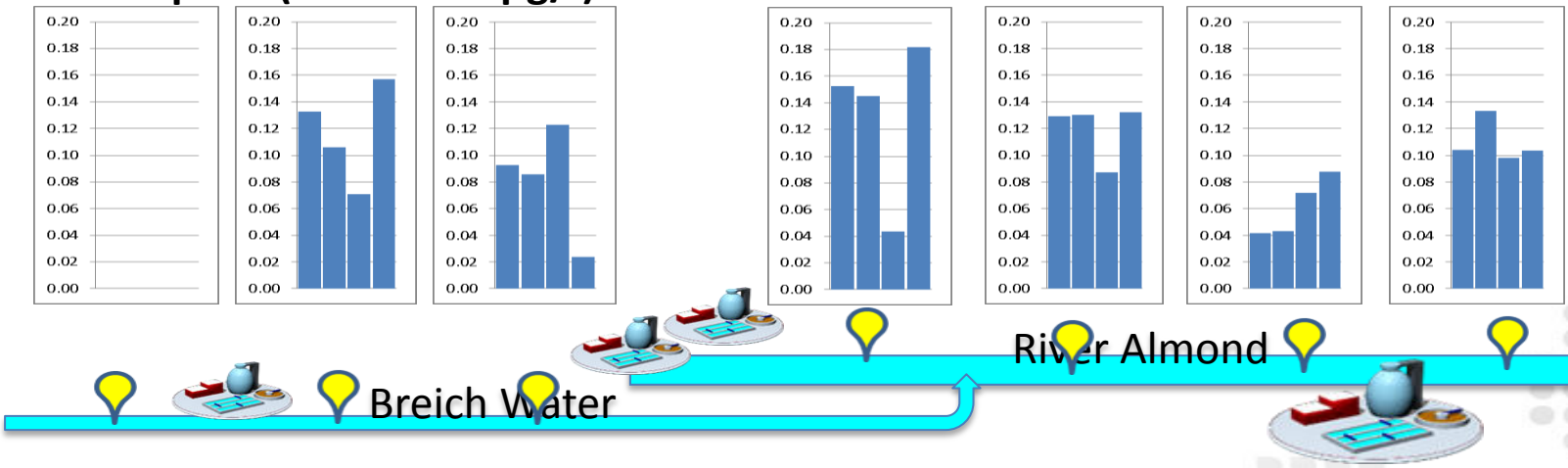
Atenolol (PNEC = 30µg/l)



Bezafibrate (PNEC = 0.46µg/l)

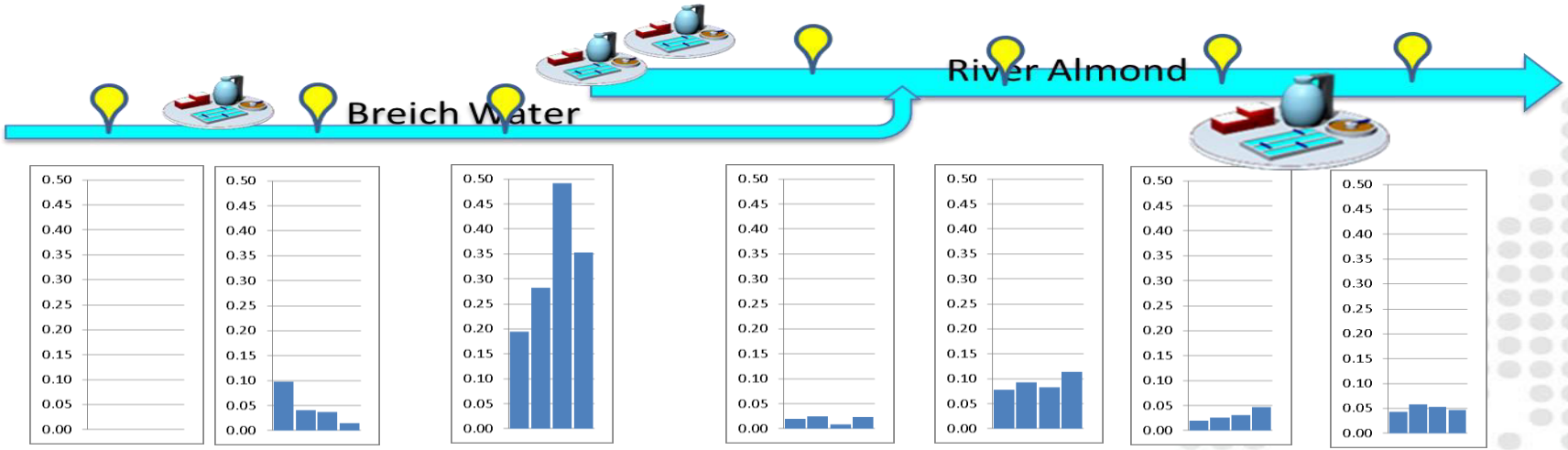
Spatial and Temporal Variation

Carbamazepine (PNEC 0.42 µg/l)



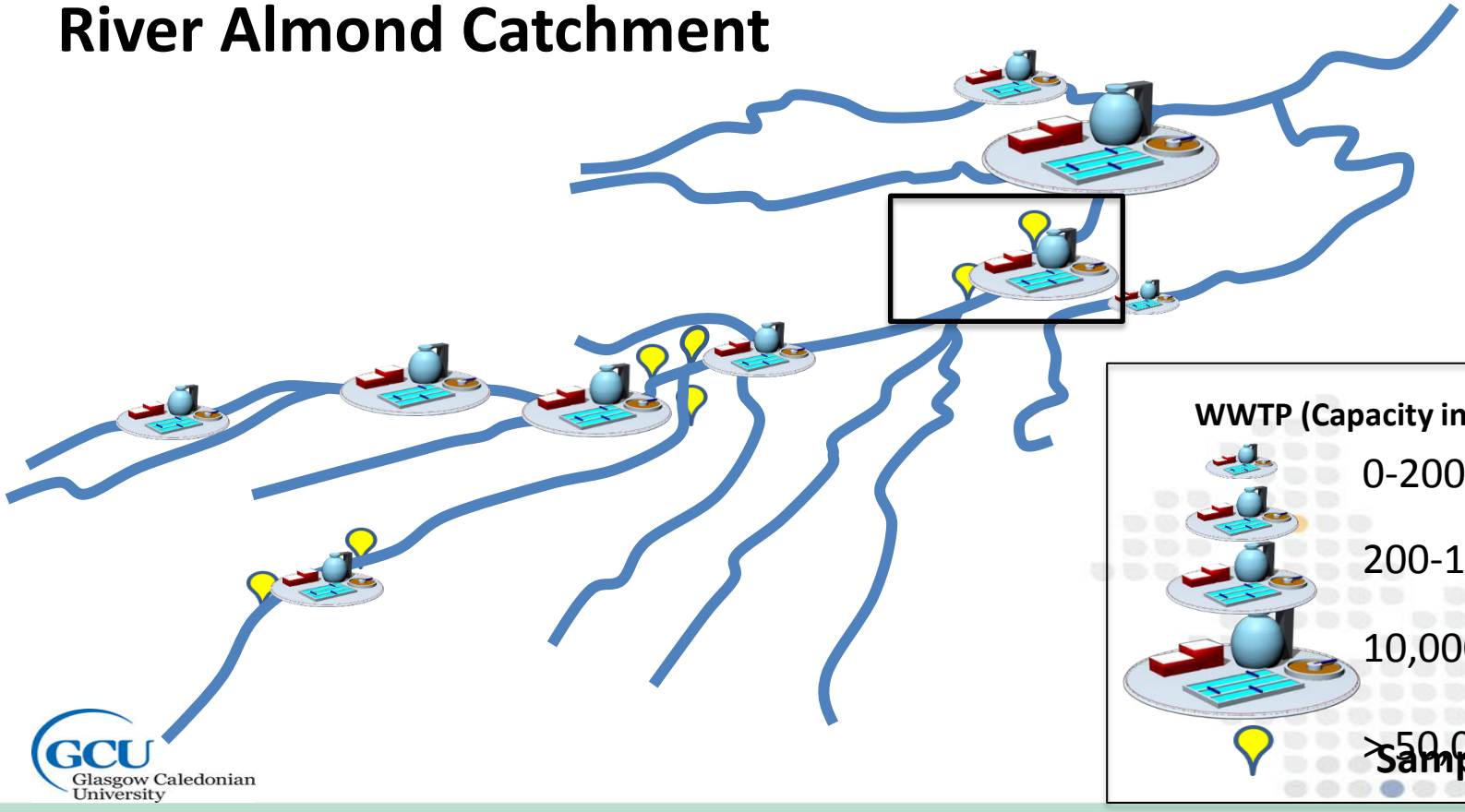
Clarithromycin (PNEC 0.07 µg/l)

Spatial and Temporal Variation



Lidocaine

River Almond Catchment



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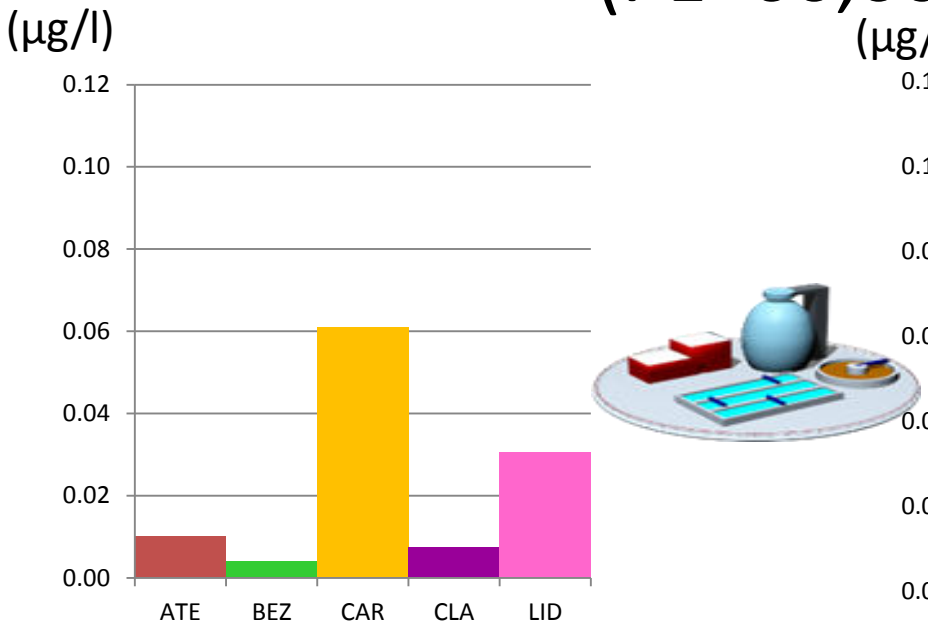
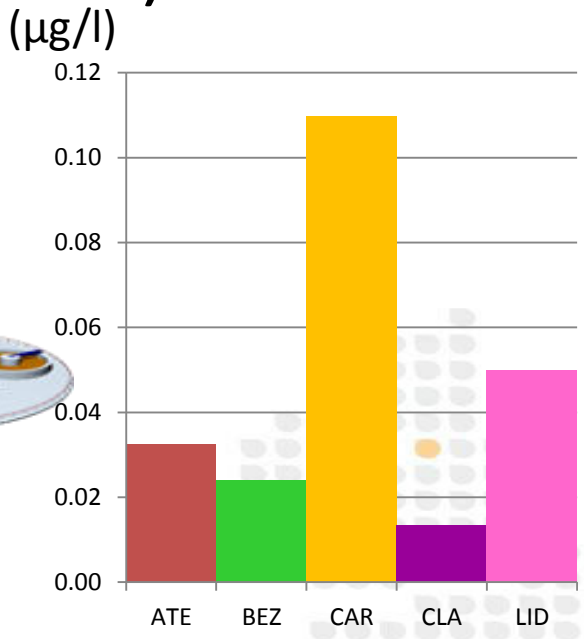
Upstream and downstream from large STW (PE=60,000)

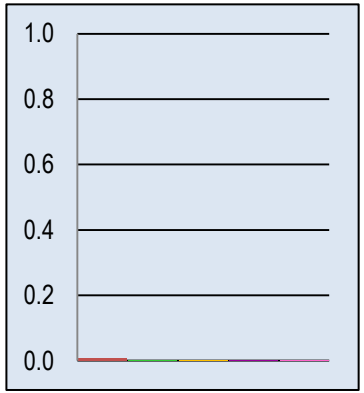




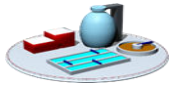
Mean concentrations increase by a factor 1.5 to 6

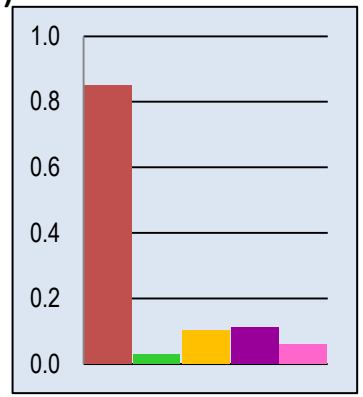
Concentrations Breich Water

(µg/l)



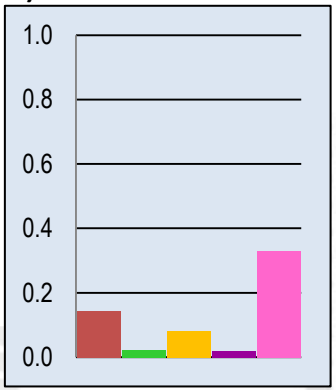
(µg/l)





←10km→

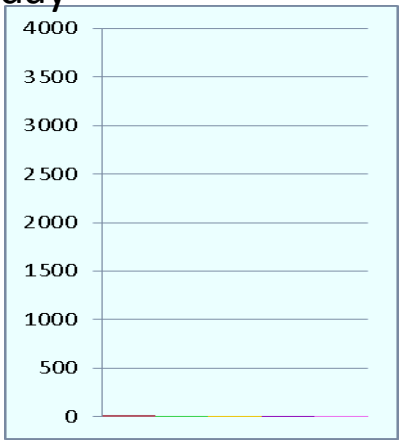
(µg/l)



Atenolol
Bezafibrate
Carbamazepine
Clarithromycin
Lidocaine

Calculated Loads Breich Water

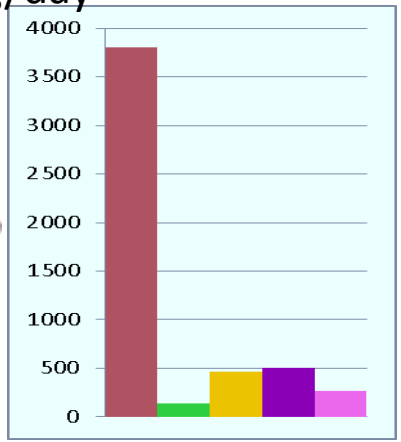
mg/day



Loc1:

Upstream from STW (flow based on measurement at Loc2)

mg/day

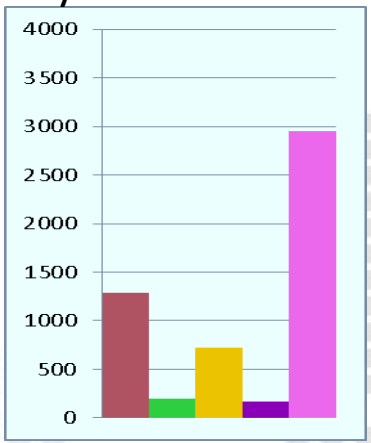


Loc2:

0.4km downstream from STW
Based on measured flow

←10km→

mg/day



Loc3:

10km downstream from STW
Based on flow estimated from relative catchment size

Controlled Activity Regulations (CAR) Authorisations

Summary

- Many of the compounds are present at (chronic) toxic levels (RQ>0.1)
- Significant rise in concentration after addition of WWTP discharge
- Suspected additional inputs from non-point sources

Future work

- Confirm results (sampling campaign planned for June ‘15)
- Investigate possible diffuse sources or minor point sources
- Repeat in wet weather (influence of CSO)

Thank you for your attention

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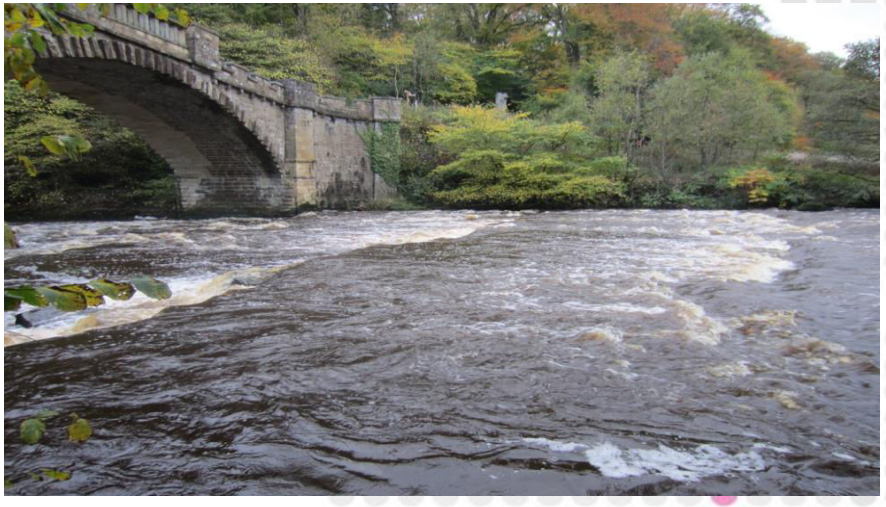

Toxicity and Persistency

Compound	PNEC (µg/l)	Reference	Removal in WWTP (Verlicchi et al., 2012)
Atenolol	30	Boillot (2008), in: Verlicchi et al., 2012	38
Bezafibrate	0.46	Isidori et al., 2007	61
Carbamazepine	0.42	Ferrari et al., 2003	18
Clarithromycin	0.07	Boillot (2008), in: Verlicchi et al., 2012	40
Lidocaine	nd		nd

Defined Daily Doses of the investigated drugs

Drug	DDD
Atenolol	75mg
Bezafibrate	600mg
Carbamazepine	1000mg
Clarithromycin	500mg
Lidocaine	n/a

References

- Ferrari, B., Paxeus, N., Lo Giudice, R., Pollio, A., Garric, J. (2003) *Ecotoxicological impact of pharmacetuicals found in treated wastewaters: study of carbamazepine, clofibric acid, and diclofenac.* Ecotoxicology and Environmental Safety 55, pp 359-370
- Isidori, M., Nardelli A., Pascarella, L., Rubiono, M., and Parrella, A. (2007) *Toxic and genotoxic impact of fibrates and their photoproducts on non-target organisms.* Environmental International 33: 635-641
- Verlicchi, P., Al Aukidy, M., Zambello, E. (2012) *Occurrence of pharmaceutical compounds in urban wastewater: removal, mass load and environmental risk after a secondary treatment – a review*. Science of the Total Environment 429, pp. 123-155