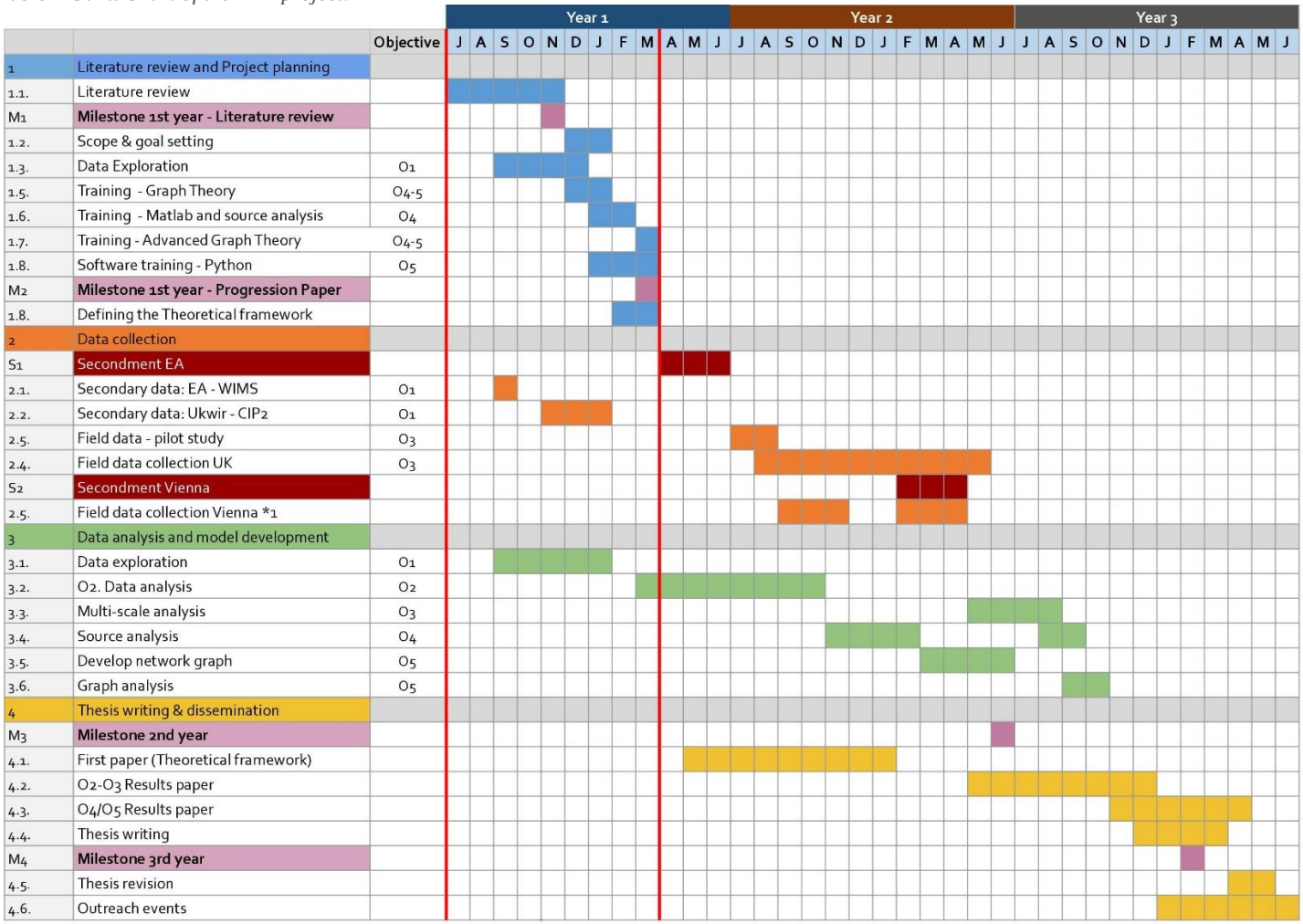
Source	Reference	Study substance	Location	Main findings
Hospital effluent	(Azuma et al., 2019)	58 pharmaceuticals (11 therapeutic classes)	Japan	Contribution of hospital effluent to STP influent pollution load estimated as 0.1% to 15% Contribution of STP effluent to river water 32% to 60% for some classes
	(Santos et al., 2013)	78 pharmaceuticals	Portugal	The contribution of hospitals to the input of pharmaceuticals in urban wastewaters widely varies, according to their dimension NSAIDs, analgesics and antibiotics are among most represented groups
Manufacturing	(Larsson et al., 2007)	59 pharmaceuticals	India	Treated effluent samples contained the highest levels of pharmaceuticals reported in any effluent
Improper disposal	(Vatovec et al., 2016b)	51 pharmaceuticals	USA	Drug disposal among this university student population does not appear to be a major source of pharmaceuticals in wastewater
Combined sewer overflow (CSO)	(Kay et al., 2017)	5 pharmaceuticals	UK	CSO found to have significant contribution to pharmaceutical load No dissipation of the study compounds was found over a 5 km length of river despite no other known inputs to the river
Sludge application runoff/leaching	(McClellan and Halden, 2010)	72 pharmaceuticals and personal care products	USA	Half of the analytes were detected in biosolid samples and 6 analytes were predicted to have problematic concentrations in porewater after land application (antibiotics ciprofloxacin, ofloxacin and tetracycline, the stimulant caffeine and two sanitizing agents triclosan and triclocarban)
Manure runoff	(Kay et al., 2005)	3 pharmaceuticals	UK	A plot study identified runoff after slurry application as a route by which veterinary antibiotics may be transported to surface waters, recommending incorporation immediately after surface application
Landfill	(Rodríguez-Navas et al., 2013)	27 human pharmaceuticals	Mallorca (Spain)	12 compounds were identified in the leachates, landfills identified as pathway to groundwater aquifers
Animal husbandry	(Jia et al., 2011)	19 sulfonamides and 5 metabolites	China	PCA apportionment showed that animal husbandry contributed 15.2% of total sulfonamides, while human sources contributed 28.5%

Decision factor	Suitable catchments	References
Data availability (spatial resolution)	Aire, Tees	WIMS dataset (most sampling sites)
Data availability (temporal resolution)	Ouse, Tees	WIMS dataset (most samples taken)
Land use (rural-urban comparison)	To be determined	Digimap land use map
Logistics	Tyne, Tees, Wear	Proximity to Durham, for ease of access
Priority catchment management	To be determined	EA expertise
Representative for UK context	To be determined	EA expertise

Decision factor	Suitable compounds	References
Data availability (spatial resolution)	To be determined	WIMS dataset
Data availability (temporal resolution)	Caffeine, Carbamazepine, Gabapentine, Crotamiton, Codeine, Lamotrigine	WIMS dataset (most sampling dates)
Data availability (both datasets)	Atenolol, Azithromycin, Carbamazepine, Clarithromycin, Diclofenac, Erythromycin, Ibuprofen, Metformin, Propranolol, Ranitidine, Sertraline	WIMS dataset and CIP database (compounds found in both)
Environmental risk	Diclofenac and Ethinylestradiol	Most often prioritized in a review of prioritization methodologies (Burns et al., 2018b)
Chemical stability	To be determined	Based on literature and/or stability test (pilot study)
Sensitivity required for laboratory analysis	To be determined	Based on expected concentrations in environmental samples (from literature) and university laboratory equipment capacity
Cost	To be determined	Based on guidance from the Analytical Laboratory staff

Data type	Source	Description
Demographic data	Nomis	2001 and 2011 Census data (England and Wales) including population, age structure, household income can be queried based on postal area codes
Pharmaceutical use data	IMS Health, OECD reports, Google searches	Pharmaceutical sales/prescription values for different compounds or rankings Sales have also been estimated based on Google search trends (Mavragani et al., 2016)
Discharge data	NRFA, rnrfa R package	National River Flow Archive (NRFA) data: time series of daily streamflow discharge and catchment rainfall
Water body classification data	EA Catchment Data Explorer	Classification objective outcome, Reason for environmental issues, Measures data, Water body to protected area links data, Objectives data for each river basin district (RBD)
WWTP locations	UWWTD	WWTP discharge point location data from the EU-wide Urban Waste Water Treatment Directive (UWWTD) data reporting repository (individual points of discharge from treatment plants or collecting systems, type of receiving area into which the effluent/wastewater is discharged, related waterbody (or river basin), information on the discharge on land)
Land cover	Digimap	2015 UK land cover map
Sewage infrastructure	Ordnance Survey (OS), water companies	
Stream map	OS Open Rivers	Water course and hydro node shapefiles
Catchment boundaries	National River Flow Archive	ESRI shapefiles for UK river catchment boundaries.

Table 1 Gantt Chart of the PhD project.



[1] The i-CONN project includes secondments with partner institutions, in this case, the BOKU university in Vienna. As of the editing of this document, activities to be conducted during the secondment remain to be determined. Two possibilities are (a) apply analyses and network-approached developed for UK catchments for a local catchment using either existing pharmaceutical data or field data collected during the secondment or in advance by collaborators at BOKU or (b) learning to use community composition analysis applied by ESR 8 for invertebrate macro-communities to investigate patterns in pharmaceutical mixtures.

Name and project title	Julia Costescu Understanding how pharmaceutical pollutants move through river catchments	
Supervisors	Prof. Louise Bracken, Dr. Laura Turnbull-Lloyd, Damian Crilly	
Source(s) of funding if available	i-CONN ITN funds	
Resource requirements	**Timing (if known)**	**Resources required (e.g. Department car, cameras, project-specific IT, fieldkit, laboratory facilities)**
UK fieldwork	Initial grab sampling campaign – provisional time late summer 2021 Subsequent sampling campaign 2021-2022	Department car(s) may be required for initial sampling campaign (multiple if several colleagues are recruited to help collect samples at the same time at several locations). Sampling kits (glass vials, filters, icepacks etc.) Possibly autosamplers, depending on results of initial sampling campaign. Laboratory facilities for sample preparation and analysis.
Non-UK fieldwork	None planned at the moment (secondment fieldwork possible but undetermined)	None planned at the moment.
Conference Attendance	i-CONN events – to be determined (planning by network)	Covered by i-CONN ITN
IT requirements (if more than standard University provision)	-	MATLAB and ArcMAP licenses (already obtained)
Laboratory analysis (include approximate sample numbers if known)	Depending on sample collection (analysis within 5-7 days most likely)	Water sample analysis (LC-MS) for pharmaceutical compounds