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Water industry strategies to manufacture doubt and deflect blame for sewage pollution in England

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The water and sewerage companies (WaSCs) in England are majority-owned by a range of global investors. The industry is under intense scrutiny for widespread failure in its environmental performance, discharging 12.7 million monitored hours of untreated wastewater and sewage into English waterways between 2019 and the end of 2023. At the time of writing, multiple investigations by environmental and financial regulators are in progress, and regulatory oversight is under review by the recently formed Office for Environmental Protection. While limited monitoring hid the full extent of underperformance, we argue that the WaSCs have prolonged this environmental disaster through strategies that mirror those of other large polluting industries in the past. We test this hypothesis for the nine major WaSCs in England against a published framework of 28 'greenwashing/deception' tactics of large industries. We identified 22 of these tactics that could be seen as disinformation, greenwashing and manufacturing doubt. The financial exploitation of water resources in England, alongside long-term degradation of infrastructure and ineffective regulation, raises globally important issues around water security, ethics and environmental stewardship. Much greater scrutiny of both industry performance and industry communication is required.

The disinformation playbook[1,2] has been used by numerous industries to stymy regulation and litigation and maintain profits[3–6]. Researchers have reported commonalities between industries in how they and their sponsored lobbyists distract, delay and disrupt the spread of information[1,2,5–8]. Commercial success does not have to mean environmental degradation, but these strategies often arise owing to conflicts of interest[9], tipping the balance in favour of profit margins over those of human and ecosystem health. When challenged on their environmental performance, polluting industries have been shown to employ tactics such as denial, disruption, distraction, distortion, deflection, casting doubt and ultimately delay through the impacts of this disinformation[10,11].

Several frameworks have been proposed for assessing an industry's capacity to 'spin the science'[5,6]. For example, Legg et al.[5] examined the literature on corporate attempts to influence science and the use of science in policy from eight sectors that pollute and impact human health, including the alcohol, tobacco, chemical, food/drink, fossil fuel, gambling, pharmaceutical and medical technology industries. The authors identified common strategies employed by these industries, including 5 macro-, 19 meso- and 64 micro-strategies[5]. Their results include common strategies such as 'activities to influence the science', including manipulation of scientific methods; reshaping criteria for establishing scientific 'proof'; threats against scientists; and clandestine promotion of policy reforms that increase reliance on the

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industry evidence. Five sectors used the same five macro-strategies, while the remaining three sectors had four of five macro strategies in common. The authors concluded that their analysis demonstrated how these strategies maximize the volume, credibility, reach and use of industry-favourable science while minimizing the same aspects of industry-unfavourable science. In a similar study, Goldberg and Vandenberg[6] identified 28 discrete tactics employed to combat scientific evidence or promote narratives that favour big corporate enterprises, such as coal, oil, sugar, tobacco and pesticide industries, and non-governmental organizations associated with spreading doubt over climate change. Five tactics were commonly used across these sectors, including attacking research study design, enlisting the support of 'reputable' individuals, misrepresenting information, employing hyperbolic or absolutist language and influencing government agencies or laws. A further ten commonly used tactics relied on logical fallacies—a well-established form of rhetorical manipulation.

This article examines the communications and behaviours of the water and sewerage companies (WaSCs) in England over the period 2019–2023 for evidence of any of the 28 tactics identified by Goldberg and Vandenberg[6]. While the framework of 'strategies' by Legg et al.[5] and 'tactics' by Goldberg and Vandenberg[6] have much in common, Goldberg and Vandenberg[6] place greater focus on communication strategies directed at the public (Supplementary Table 1), which more closely aligns with the aims of this analysis. For example, tactics such as 'appeal to emotion', 'taking advantage of scientific illiteracy' or 'taking advantage of the victim's [public] lack of money or influence' were more applicable to the communications observed by the water industry in England. Examples in this study come from multiple sources, including government agency reports, transcribed committee minutes/reports, water company websites, information leaflets and social media communications, and some of our own research experiences. Tactics, as defined by Goldberg and Vandenberg[6], are highlighted in the text by the respective number from Table 1 preceded by a 'T' (that is, T1–28). To our knowledge, this is the first such examination of English WaSCs. This analysis aims to provide evidence to test the hypothesis that the WaSC industry may have actively maintained the status quo through 'manufactured doubt' and 'spin'.

Background to the UK water industry

Most of the water industry in the UK was privatized in 1989, with England split into 9 privatized WaSCs and a further 13 smaller companies providing potable drinking water services only. The water company in Wales was left as a not-for-profit company, leaving only Scotland and Northern Ireland under public ownership. Complications in water quality governance arise from river basins crossing boundaries between Wales and England as well as Scotland and England, but the ownership model in England is dominant (84% of UK customers) since England has a population of approximately 57 million people out of a total of 68 million in the UK. The English water industry is now 70% foreign-owned by investment firms, private equity, pension funds and businesses lodged in tax havens spread across 17 countries[12]. The financial exploitation of national water resources in England, alongside long-term degradation of wastewater treatment infrastructure and ineffective regulation, raises globally important issues around water security, business ethics and environmental stewardship. Privatized WaSCs in England are thought to be carrying £56 billion (~US$68 billion) in debt (in 2023) while reportedly having paid out £76 billion (US$92 billion) in shareholder dividends since privatization[12]. In June 2023, an emergency meeting took place between the financial regulator (the Water Services Regulation Authority, Ofwat), the Department for Environment, Food and Rural Affairs (DEFRA) and the UK Treasury owing to concerns that Thames Water (with 15 million customers, the largest WaSC in England) was on the brink of financial collapse and unable to service its debts[13]. This raises the question of whether global investors can be held to account for a WaSC's environmental performance, which includes discharges of untreated sewage, clean water leaks and predicted water resource shortages exacerbated by climate change[14].

The Environment Agency (EA) in England polices the environmental performance of English WaSCs. Between 2019 and 2023, there were approximately 1.7 million monitored discharges of untreated sewage and wastewater to English rivers and coasts, totalling 12.7 million hours, equivalent to almost 1,500 years (Table 2, Fig. 1 and ref. 15). Many of these discharges breached the permits issued by the EA and are suggested as illegal (that is, non-permitted discharges)[16,17].

Multiple investigations into the water industry and its regulators are ongoing[17]. The environmental regulator, the EA of England, and the financial regulator, Ofwat, are investigating the WaSCs[17]. The UK House of Lords is also investigating Ofwat[18]. The Office for Environmental Protection (OEP), which was formed in 2021, is investigating the performance of the EA, Ofwat and DEFRA. An interim report by the OEP (2023) concluded that "we believe that there may have been failures to comply with environmental law by all three of the public authorities"[19]. In addition, two high court actions were granted in 2023 for judicial reviews into Ofwat and DEFRA's stormwater overflow reduction plans[20]. In August 2024, Ofwat recommended that three water companies in England (Thames Water, Yorkshire Water and Northumbrian Water) be fined a total of £168 million for "failing to manage their wastewater treatment works and networks, as part of the first batch of outcomes from its biggest ever investigation"[21]. In October 2024, the new UK government ordered an independent commission to review the water industry in England and Wales with the vision to "create a climate resilient and secure water sector that continues to have world-leading drinking water quality and delivers on our government's priorities for public health, enjoyment of our waters, the natural environment, economic growth and food security"[22].

WaSCs have two principal responsibilities that involve the provision and maintenance of suitable infrastructure: (1) to supply clean drinking water to customers and (2) to collect domestic/commercial/industrial wastewater and discharge it back to the environment once it has been treated to agreed national/international standards. In its 2022 annual performance report, the EA said: "In 2021, the environmental performance of England's 9 water and sewerage companies was the worst we have seen for years"[15]. Water companies are given a star rating for their environmental performance. The report's summary states that, when measured against a top 4* rating, most had gone in the wrong direction, with four companies on 2* (requiring improvement) and a further two companies given a 1* rating (poor). The report describes the sector's performance on pollution as "shocking, much worse than previous years". In a damning critique of the way the water industry is managed, the 2022 EA report states:

> "Company directors let this occur and it is simply unacceptable. Over the years the public have seen water company executives and investors rewarded handsomely while the environment pays the price. The water companies are behaving like this for a simple reason: because they can."

The EA reported 1,677 pollution incidents and 62 serious pollution incidents during 2021[15]. The terminology for describing the amount of precipitation (exceptional, extreme and heavy) varies between water company websites. The evidence that has recently emerged shows that light/average precipitation is sufficient to activate many storm overflows[16,17]. Activation may also be initiated by groundwater infiltration into leaky sewerage pipes. The EA does not accept such infiltration as an excuse for storm overflow use, considering it to be in breach of the discharge permit[23]. The European Court of Justice ruled in 2012 that the UK Government's attempt to allow discharges during 'heavy rainfall' was not acceptable and insisted that such discharges

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Table 1 | The 28 tactics identified by Goldberg and Vandenberg (2021) that industries use to manufacture doubt and examples we identified from England's water industry for 22 of these

Number	Tactic	Examples used by the water industry
T1	Attack study design	• Water companies have attempted to discredit work by scientists that has highlighted breaches of sewage discharge permits
T2	Gain support from reputable individuals	N/a
T3	Misrepresent data	• Spill data—accepted by the EA and water companies as not accurate and in breach of permits (Environmental Audit Committee (EAC) minutes) • Both Thames Water and Southern Water fined for misrepresenting data • Impact of spill data (Reasons for Not Achieving Good Status; RNAGS) are misrepresented as the frequency and quantify of discharges are unknown • Declare that sewage discharges are not raw sewage or play down the severity of spill concentrations
T4	Suppress incriminating information	• Prevented and hid data from EA inspectors (judges summing up) • Refuse/delay Freedom of informtion (FOI) requests—widely reported in the media and more recently during BBC investigation into dry spills
T5	Contribute misleading literature;	• Evidence of using outdated literature • Misleading public communications over the dilution of stormwater overflows and the impact of CSOs on overall water quality • Deny discharges are raw sewage
T6	Host conferences or seminars	• Host conference whereby the main focus is influencing customer behaviours as a means of deflecting blame
T7	Avoid/abuse peer review	N/a
T8	Employ hyperbolic or absolutist language	• Play down environmental impacts of discharges and play up the impact on people's homes if they were not to discharge sewage, for example, flood schools and hospitals with sewage • Alarmist figures to fix the problem (£660 billion), which focuses on increased bills for customers
T9	Blame other causes	• Blame the farming industry, road run-off and people putting incorrect things such as fats and sanitary products down the toilet. These are all valid, but when is this education versus deflection? • Considerable investment in the education of other causes and playing down their own impacts
T10	Invoke liberties/censorship/overregulation	N/a
T11	Define how to measure outcome/exposure	• They have been policing themselves, so they have been defining how to measure outcomes. Self-reporting of discharges has been shown to be inaccurate • Defining discharges as impacting and non-impacting • Been allowed to define what exceptional circumstances are, with large variation in terms used by different water companies
T12	Take advantage of scientific illiteracy	• 95% of rainwater claims and just grey water rely on the perception that the public will not know it might be inaccurate or how bad the other 5% might be. • Inaccurate claims relating to the age of the England sewage and wastewater infrastructure
T13	Pose as a defender of health or truth	• UK Water argues that the water industry has been responsible for cleaning up the rivers since the 1950s as opposed to being responsible for their poor water quality • 'The truth about English rivers', written by the body representing the UK water industry, uses inaccurate and outdated data to support claims that critics are wrong • Uses language such as 'sound science' adopted by other polluting industries to seed doubt
T14	Obscure involvement	N/a
T15	Develop a public relations strategy	• Evidence of similar and coordinated messaging by the industry representative lobby UK Water.
T16	Appeal to mass media	• Develop a coordinated strategy that makes business appear greener and more healthy
T17	Take advantage of victim's lack of money/influence	• 'This will cost the consumer more if we have to improve the infrastructure'
T18	Normalize negative outcomes	• Highlight that the discharges are normal and heavily regulated when in fact they should only be used in 'exceptional circumstances' • Develop approaches whereby water users find it normal to check for sewage discharges before taking part in water-based recreation
T19	Impede government regulation	• EA officers were impeded from getting data from water companies
T20	Alter product to seem healthier	• The Storm Water Task Force Group has been changed to the Clean Rivers and Seas Task Force by Southern Water • Wastewater treatment plants have been rebranded as water recycling sites • The industry has recently put themselves forward as the group that helped clean up the rivers • We are protecting homes and businesses
T21	Influence government/laws	• The scaremongering about the bill to stop stormwater overflows focussed on costs that may have influenced the more nuanced language used by the government to 'progressively reduce' • The government uses terminology and figures generated by the water industry
T22	Attack opponents	• Discredit work of scientists that highlights that sewage discharges may have been in breach of permits
T23	Appeal to emotion	• Emotive language used in communications with the general public, for example, without stormwater releases, schools and hospitals would be flooded
T24	Inappropriately question causality	• Just 4% impact on water quality, when the real impact is unknown without more accurate data on sewage discharge volumes
T25	Make straw-man arguments	• Not 'raw sewage' • Focus on agriculture doing harm
T26	Abuse credentials	N/a
T27	Abuse data access requests	• BBC: "The remaining six water companies in England said they couldn't provide information because they were already being investigated for potential illegal spilling by industry regulator Ofwat and the EA"
T28	Claim slippery slope	N/a

N/a, tactics for which we did not find evidence; EA, Environment Agency; CSO, combined sewer overflow.

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Table 2 | Numbers and duration (hours) of known sewage and wastewater discharges into rivers and coastal waters in England between 2019 and 2023 (ref. 15)

Year	Number of known sewage and wastewater discharges	Hours of discharges (millions)
2019	292,864	1.5
2020	403,171	3.1
2021	372,533	2.7
2022	301,091	1.8
2023	464,056	3.6

are permitted only in 'exceptional situations'. A damning 2022 report by the House of Commons Environmental Audit Committee (EAC) in its 4th Water Quality in Rivers Report[24] highlighted

> "…that rivers in England are in a mess. A 'chemical cocktail' of sewage, agricultural waste, and plastic is polluting the waters of many of the country's rivers. Water companies appear to be dumping untreated or partially treated sewage in rivers on a regular basis, often breaching the terms of permits that on paper only allow them to do this in exceptional circumstances."

The looseness of the term 'exceptional' has provided a loophole in the legislation that has been widely exploited (T11). For example, Hammond et al.[16] demonstrated that water companies were substantially underreporting the number of untreated sewage discharges, many of which occurred under 'normal' rainfall or even during dry weather. At two wastewater treatment plants (WWTPs), almost 1,000 previously unreported spills were identified, with many violating permits to discharge water via storm overflows[16]. Further reports by the same authors, analysing monitored discharge data obtained by freedom of information request from WaSCs, have identified more than 5,000 days of sewage spills in breach of permits[16]. The accumulation of hotspots of microplastic contamination on riverbeds also points to the routine discharge of inadequately treated wastewater into rivers under conditions of low river flow[25]. An earlier study showed that even moderate rainfall and flooding were sufficient to wash microplastics downstream and prevent them from accumulating on riverbeds[25,26]. As such, the recovery of large quantities of riverbed microplastics downstream of a WWTP or combined sewer overflow (CSO) is clear evidence of untreated wastewater discharges during light/normal rainfall (or during an otherwise dry period). These two studies were published just 2 months apart in 2021; both provided compelling evidence of untreated wastewater discharges into low river flows or dry weather spills in English river catchments. The water industry immediately refuted each of the study's designs (T1) and assumptions (T22)[27–29], yet when challenged to provide evidence to the contrary, to our knowledge, none has been forthcoming. The data from some of these reports (for example, refs. 30 and 31) was subsequently used as evidence by Ofwat in fines totalling £158 million to Thames Water, Yorkshire Water and Northumbrian Water[32].

Academics and campaign groups wanting to understand the frequency, severity and risks posed by sewage discharges in England have routinely had environmental information requests (EIRs) denied (T27 and T4) or incomplete datasets provided after prolonged delay (T4)[33,34]. It is a legal requirement that all EIRs be satisfied within 20 working days unless extensions are requested. A 2023 analysis of spill data from three water companies by BBC researchers in collaboration with several UK universities has confirmed that dry weather spills are widespread and routine[35]. In response to the BBC investigation, representatives from both Southern Water and Wessex Water reported that "dry spills are a complex issue" and "often arise due to infiltration of groundwater"[35]. Six water companies said they were unable to provide information to the BBC investigation because they were already being investigated for potential illegal spilling by industry regulators Ofwat and the EA[36]. Subsequently, the UK Information Commissioner's Office reported in July 2024 that a recent tribunal case[36] found that a legal exception, which says releasing information will prejudice an investigation, did not apply to the information requested through EIRs[34].

Fig. 1 | CSO duration for 2023. Circles show individual overflows, with the size being proportional to duration (0–8,700 h) and the colour differentiating the WaSCs. Figure adapted from Top of the Poops under a Creative Commons license CC BY-SA 4.0.

The use of fines by regulators has not improved standards. Summing up in the *EA* v. *Southern Water Services Limited* case[37] in July 2021, which was the largest investigation in the EA's 25 year history, the judge stated

> "Southern Water Services Limited has pleaded guilty to 51 counts of discharging untreated sewage into controlled coastal waters… It has been estimated that the total volume of untreated sewage across all of the sites was in the region of 16–21 billion litres."

> The court heard that, when "…the Environment Agency sought to investigate these offences it met a level of obstruction that it says was unprecedented in its experience of a company of this size. On multiple occasions, employees refused to permit Environment Agency officers to take away documentation that it wished to seize under its statutory powers, refused to allow them to walk around sites unaccompanied, citing 'health and safety', and refused to answer questions, despite the Agency's powers to require answers."

These offences (T4) led to the largest ever fine of a UK water company of £90 million[37]. In July 2023, Thames Water was fined £3.33 million for discharges of raw sewage into rivers[38]. In summing up, the judge[39] said she believed Thames Water had shown a "deliberate attempt" to mislead the EA by omitting water quality data readings and submitting a report to the regulator denying responsibility (T3, T4 and T19).

How the water industry in England spins science

The water industry and its representatives proactively and reactively communicate with the public. The following are typical examples of such communication, which have been evaluated for evidence of the manufacture of doubt and spin[6]. Biocide industries have been documented rebranding their insecticides, pesticides, fungicides and herbicides as 'plant protection products', which softens their image from an industry that aspires to kill target organisms to one that offers protection. Similarly, WaSCs have introduced alternative terms as part of a public relations strategy to make their operations appear greener. For example, the term 'water recycling centre' began to replace 'sewage treatment works'[39]; Southern Water's Storm Water Task Force was rebranded as the Clean Rivers and Seas Task Force. These could be viewed as a coordinated strategy to make the business appear greener (T15, T16 and T20).

When challenged about stormwater releases, the water industry has repeatedly refuted that they discharge 'raw sewage'. This term is graphic and emotive and can be visualized by the public very easily (T23). Examples of how the industry has softened this terminology can be found in Box 1. The industry routinely utilizes alternative phrases that metaphorically dilute the offensive connotation to the point that they are no longer accurate (see rebuttal in Box 1) (T3, T5, T8 and T12). The water industry has also tried to play down the severity of storm overflow discharges by describing their impact as 'insignificant', 'minimal' or 'temporary'. These are disingenuous because, of the 370,000+ CSO spills in 2020, only 11% were investigated by the EA for impact[40–43], ensuring that no one can truly know that the impact is minimal. Moreover, sewage is just one component of untreated wastewater, which contains millions of putative human pathogens and antimicrobial resistance genes per litre[44] as well as high levels of nutrients and microplastics, and hundreds of micropollutants, making it likely that its discharge to a river would be impactful from the perspective of several metrics, especially if such discharges are chronic, as many are[45,46]. Wessex Water state on their website that stormwater overflows have 'minimal or no ecological impact', yet they also claim the following:

> "We don't currently know the real time impact storm overflows have on water quality. It is possible that a storm overflow that discharges for a couple of hours could discharge less harmful sewage than a storm overflow that discharges for just 30 minutes. It all depends on the contents of the combined sewer at the time of heavy rainfall."[47]

Therefore, we conclude that the messaging from the water companies is mixed and errs on the side of minimizing the impact of the sewage spills (T5 and T12).

The water industry and regulatory authorities refer to the use of screening to remove solid objects (not faeces), as 'preliminary treatment', suggesting that the components of sewage that people are most concerned with (that is, the faeces and pathogens) have started to be removed, which they are not (T11, T12, T20 and T23)[48]. Referring to sewage discharges as 'preliminarily treated' gives the public a false impression of the risk, playing down the potential harm to human health and the environment that can be caused from its discharge to the environment. For example, Thames Water highlights that "we've needed to significantly extend Mogden [WWTP] to reduce the number of times partially-treated sewage overflows into the River Thames when the works become overloaded after heavy rain"[49]. Screened sewage is identical to the pre-screened sewage in every significant biological and chemical metric (T3, T5, T8, T11, T12, T13 and T20), thereby posing nearly identical environmental and human health threats as unscreened sewage[50].

Another variation on these rebuttals from the water industry is to claim that it is not raw sewage but 'grey water' as it has been diluted by other household discharges (Box 1), which often gives the domestic waste a grey appearance. Thames Water recently described grey water as "relatively clean waste water from baths, sinks, washing machines and other kitchen appliances"[51]. Discharges still contain raw sewage, regardless of the colour, not to mention that the 'sewage fungus', which gives rivers a grey appearance, is actually a complex of bacteria, not fungi (T5). Furthermore, they still contain harmful faecal pathogens at concentrations that exceed legal limits[22,52], as well as discharges from dishwashers, showers and washing machines that contain chemicals known to be toxic to aquatic wildlife[53,54].

Industry communications will often alter the meaning of key terms by softening terms, such as 'heavily diluted wastewater', 'mainly rainwater' and 'pretty much rainwater' (T5 and T8; Box 1). A common industry phrase communicated across social media is that wastewater discharges "were 95% rainwater" (Southern Water) or, in some cases, "99% rainwater" (South West Water) (Supplementary Fig. 1). Given that all pipes have a different degree to which they are already filled with sewage (that is, dry weather flow), it is not possible to say what proportion of the CSO discharge is composed of sewage and rainwater—it will depend on many factors, including time of day, as the pipes have the greatest free capacity in the early morning and the least free capacity at approximately 10:00[55].

Following questions by the EAC in October 2021, the chief executive officer (CEO) of Severn Trent Water repeatedly claimed that "the company did not discharge raw sewage" and "because storm overflows discharged a mix of sewage 'heavily diluted' with rainwater, the contents of any discharge were 'pretty much already rainwater'"[56]. The committee suggested that, while this claim may have been intended to reassure them about the discharges from overflows on the Severn Trent network, they did not find it convincing[56]. At the same committee, the then CEO of Southern Water, in response to questioning, stated that "In most of our spills, the constituents are 97.1%—it sounds terribly precise, but roundabout 97% is rainwater, surface water, so not sewage"[56]. The claim that spills are so diluted that it is not sewage we believe to be factually incorrect. The attempt at precision for a highly variable measurement further reinforces the impression that the industry wishes to be seen as an authority with a rich understanding of its business and its possible impacts (T5). Following recent challenges by a citizen science group, SOS Whitstable, the industry has since changed these claims from "95% rainwater" to "up to 95% rainwater" (T3) (for example, refs. 57 and 58). Recent studies of stormwater discharges have found that, while they may only contribute 8% in terms of volume compared with treated effluent, they contribute more than 90% in terms of total faecal coliforms[52]. Similar studies have highlighted that CSO discharges contain very high numbers of faecal indicator species that fail approved water quality criteria[40–42]. There is considerable evidence that treatment cannot remove all pollutants, such as endocrine-disrupting chemicals, which can impact the health of ecosystems, from wastewater effluents[53,54]. These statements made by the water industry, as well as not always being factually correct (that

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BOX 1

Examples of water industry communications playing down the impact of raw sewage, taken from company web pages, 20 March 2023

Water industry quotes	Rebuttal to quotes
Quote 1: "Contrary to popular belief, stormwater releases are not 'raw sewage'. They're made up of wastewater – primarily from washing machines, showers and dishwashers – and are heavily diluted by rain." (Southern Water)	Quote 1: Stormwater releases contain raw sewage as they are derived from the sewerage system.
Quote 2: "Because of the job they do, and despite calling them 'sewer overflows', most of the water they release is rainwater, not raw sewage." (Anglian Water)	Quote 2: The sewerage system will always have sewage in it. The ability of sewers to accommodate rainfall in addition to the sewage is highly variable. Some sewers are already running near capacity and, therefore, have little to no capacity to accommodate any rainfall.[66]
Quote 3: "Although it does contain some untreated sewage, storm discharge is heavily diluted because it's mostly rainwater" and "In most cases, storm discharges are heavily diluted by rainwater. So, although they're unpleasant, their impact to river water is likely to be minimal." (United Utilities)	Quote 3: There is no room for rainwater where the sewer system is running near capacity. CSOs discharging from such a system will not experience very much dilution at all. Moreover, there is ample evidence in the academic literature to show that the level of microbial contamination in stormwater will increase in a 'first flush'[85].
Quote 4: "When we do need to use them, they can sometimes affect river and bathing water quality, albeit temporarily." (Thames Water)	Quote 4: There is no evidence that rivers are only temporarily impacted by CSOs. Many CSOs discharge nearly every day of the year, as the data show[86].
Quote 5: "Storm overflows have minimal or no ecological impact because what is released is diluted wastewater" and "Generally, storm overflows have an extremely small impact on rivers." (Wessex Water)	Moreover, there is no systematic data being collected to assess whether the downstream environment is impacted, only temporarily, from CSOs. Quote 5: Same response as to quotes 2, 3 and 4.
Quote 6: "Storm overflows have not been routinely built into sewers since the 1960s, but over 14,000 of them remain in England. They are much less environmentally harmful than many other sources of pollution like sewage from treatment works or agricultural runoff..." (Water UK)	Quote 6: It should always be the case that CSO discharges will be more impactful to the environment than treated sewage discharges of the same volume. If this was not the case there would be no point in treating sewage. The fact that some agricultural runoff can be more impactful than CSO discharges is irrelevant.

is, misinformation; T5), could be considered as underplaying the risks to human health and the environment that arise from such discharges (that is, greenwashing and spin; T12).

'Nature-based solutions' (NBS) is the latest term used among those in restoration ecology and climate change and flood mitigation. Several industries have been accused of greenwashing through their 'net zero' and 'carbon neutral/positive' initiatives to make the public think businesses are environmentally friendly[59–61]. NBS have recently entered the UK water industry lexicon to foster environmental positivity in strategic approaches to the problem of stormwater discharges. Large-scale infrastructure changes are costly for the water industry and are communicated as impacting consumer bills (T17). In contrast, NBS approaches are seen as environmentally friendly as they do not consume as much carbon as engineering solutions such as the storm tanks used to relieve pressure on a combined sewerage system receiving rainfall. They also provide a means for the water industry to support nature conservation efforts, which helps rebuild trust and positive public relations (T13). For example, the restoration of oyster beds is considered a green alternative to dealing with high nutrient loads owing to their capacity to filter large volumes of water and form large biogenic reefs that increase biodiversity. NBS in pollution control are not new—reed beds, for example, have been used successfully for many decades to trap contaminants in the mining and water industries[62]. All conventional sewage treatment has a biological component, which is a NBS to break down organic material. The general public should be more clearly informed that nature can only provide solutions if the human pressures are sufficiently alleviated; in the case of the water industry, the need is for repairing and replacing infrastructure (T5) and, ultimately, reducing the load on sewerage networks (T12).

Following the 2021 court case of *EA* v. *Southern Water Services Limited*, the judge highlighted that oyster populations along the south coast of England had declined in areas receiving illegal sewage discharges[37]. While the declines in oyster populations could not be fully attributed to sewage, the judge stated:

> "... there is a degree of scientific consensus that a reason for a substantial part of the reduction in the oyster population is water pollution or water quality. The demise of the oyster fishery in the Solent has had a huge impact on the local economy. Conversely, modelling shows that if water quality improves there is likely to be a significant increase in the value of bivalve shellfish harvesting in the Solent"[37]

Restoration projects under the guise of NBS (for example, refs. 63 and 64) without the concomitant declines in sewage discharges mean habitats may continue to be at risk, and this whole approach could

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BOX 2

Examples of water industry communications highlighting that what they do is permitted and normal, taken from company web pages, 20 March 2023

"Storm discharges are legally allowed, under the conditions of the Environment Agency permit." (Thames Water)

"This is permitted by the Environment Agency and closely monitored by them and us." (Yorkshire Water)

"Storm overflows have minimal or no ecological impact because what is released is diluted wastewater... Although overflows are permitted by the Environment Agency, we agree that they have no place in the 21st century, but it will take time and significant investment to progressively eliminate them." (Wessex Water)

"Each of our CSOs has been assessed for the environmental risk potential, as defined by the Environment Agency, and they have each been permitted to act as a 'storm overflow'. But despite being consented by our regulator, it is understandable that no one finds it acceptable that even extremely diluted sewage reaches our rivers." (Anglian Water)

"Our storm overflows operate within the permits set by the Environment Agency and have been designed to provide excellent bathing water quality." (Northumbria Water)

be considered further greenwashing and a cynical public relations exercise (T12).

Online 'near real-time' data showing CSO discharges, now available from seven WaSCs, inform the public of sewage discharges to enable them to better control their exposure to the pollution hazard by choosing where to participate in swimming and other recreational water activities. This approach normalizes the negative outcomes of sewage discharges, making it routine for the bather to view a website before planning a day at the river or beach (T18). Southern Water has event duration monitors fitted to 100% of its wastewater and CSO outfalls, and launched in 2018 a public-facing website (Beachbuoy, https://www.southernwater.co.uk/water-for-life/beachbuoy) to inform water users of discharges in real time. Hailed as leading in the sector for the UK, the company was criticised in September 2021 for the way data are displayed to the public[65]. The real-time maps offer a traffic light system: red indicates a discharge at a specific location in the last 24 h, and yellow in the previous 72 h, with green indicating no recent spills. During heavy and/or prolonged rainfall, England's south and southeast coasts are often red with spill alerts across 700 miles (1,126 km) of coastline. The traffic light system was recently replaced with white markers instead of red, until the spill was verified as genuine. Responding to criticism, the water company told the BBC that "Beachbuoy previously did not account for tidal conditions and duration, and cautiously took the worst-case scenario, leading to flagging bathing waters, which causes unnecessary worrying for the public and the tourism industry alike. Now if the outfall is a long way out to sea, the release was short and the tidal conditions meant there could be no impact on a bathing water, the tool will no longer trigger a warning to users." Where spills are not identified as genuine within the 24 h window, markers will remain white on the map. The absence of a yellow marker means that bathers will only find out about sewage discharges retrospectively, defeating the purpose of a spill warning system[65]. Because of the uncertain quality of the discharge data, the industry has introduced a delay in its own reporting, which reduces the protective intention of the alerts and decreases the public's understanding of the true nature of spills in a region (T3).

Other modifications include dynamic outfall mapping, whereby spills are categorized as 'false alarms', plus 'genuine impacting' and 'genuine non-impacting', depending on the state of the tide. Non-impacting spills have been classified as unlikely to cause designated bathing water sites to fail faecal bacterial measurements. In July 2023, on the basis of this criticism, Southern Water changed the terminology from 'non-impacting' to 'non-impacted' to better represent the condition of the bathing water location. Critics have pointed out that these 'non-impacting' discharges or indeed 'non-impacted' discharges could well be 'impacting' water quality for human and ecological health in areas close to designated bathing water locations (T3, T11 and T12). Therefore, collectively, these are seen as a tactic to play down the impacts of sewage discharges on coastal environments.

WaSCs observed during this study highlight that the use of CSOs is normal (T18; normalizing negative outcomes) and heavily regulated by the EA (Box 2) and that, without their use, homes and businesses would be flooded with sewage (Box 3). Some companies highlight that schools and hospitals could be flooded without the discharge from CSOs. Presenting the public with a binary choice of spilling sewage into schools and hospitals or the river appeals to a simplistic argument that will allow the public to tolerate CSOs (T23; appeal to emotion). Recent studies have revealed the chronic under-capacity of the English wastewater systems as a fundamental cause behind the increased frequency and duration of CSO spills[66]. In December 2022, the CEO of the financial regulator Ofwat wrote

> "We expect companies to deliver the service improvements they were funded to deliver. No ifs, no buts" and "The lack of investment from companies we're seeing at the moment is extremely disappointing, especially in light of the poor performance for customers and the environment. Failure to invest or delays to investments means that vital improvements are not being made or are late. I am expecting these companies to get a grip on their investment programme and make up for the shortfalls to deliver the associated improvements in service."[67]

Both water companies and politicians have often blamed the current situation on historical Victorian drainage (Queen Victoria's reign ended in 1901; T3 and T12). However, while it is true that a good deal of drainage infrastructure was built during Victorian times in London (mid-1870s), much of the network in London and other cities and towns was built much later during the urban expansion of the twentieth century[68]. Furthermore, several reports have emphasized that infrastructure investment does not match population growth, climate change and increased use of impermeable surfaces[66,67].

One tactic used by those looking to manufacture doubt is to deflect causality and obscure involvement (T9 and T14) by suggesting 'it's not us, it's them' or developing a straw-man strategy (T25). There are many pressures on aquatic systems, including agriculture, industrial and domestic discharges and urban runoff. The EA has introduced metrics for rivers to determine the dominant sources behind the 'reasons for not achieving good status' (RNAGs). RNAGs attempt to apportion contributions to poor water quality to a source[69]. WaSCs frequently highlight that their contribution to rivers not achieving good status

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BOX 3

Examples of water industry communications that use emotive language, taken from company web pages, 20 March 2023

"If we didn't have storm overflows then the diluted storm water wouldn't have anywhere to go, which would result in homes, businesses and streets being flooded." (South West Water)

"When this occurs, excess water is released into rivers and the sea, to prevent homes, businesses, schools, and roads flooding.' "Storm releases are made for one reason – to protect homes and businesses from flooding. For instance, in heavy rain storm releases from our Budds Farm wastewater treatment works (and the related storm overflows) protect more than 2000 properties including schools and hospitals." (Southern Water)

"At times of heavy or continued rainfall, the sewer system can't always cope with the extra volume. Storm overflows are used to prevent sewers flooding our homes, gardens and streets. They act as a safety valve, diverting some of the rainwater and foul water into watercourses. We call this mixture 'storm discharge'." (Thames Water)

"As rainwater can be unpredictable, we have permitted storm overflows on our sewer network to act as a relief valve. They help to reduce the pressure on sewers during heavy rainfall events and stop the system from backing up and flooding homes and gardens by allowing heavily diluted wastewater to be discharged into watercourses." (Yorkshire Water)

"Sewers operate this way to help prevent the flooding of streets, homes and businesses." (United Utilities)

"Storm Overflows (SOs) help protect homes, buildings, and land from flooding. They're 'backup sewers', and collect overflowing stormwater when our normal sewers are overloaded due to heavy rainfall. Spills to environment contain mainly rainwater along with dilute sewage and are screened to remove debris." (Northumbria Water)

BOX 4

Examples of water industry communications deflecting or playing down issues of poor water quality, taken from company web pages, 20 March 2023

"Did you know agricultural runoff is the biggest polluter of rivers and waterways as it often carries along pesticides, fertilisers and animal slurry?" and "Agricultural impacts alone account for 46% of the reasons for poor river health in our region." (South West Water)

"The Environment Agency estimates that storm overflows lead to around 5% of river and sea pollution in the North West, with water quality in the natural environment affected by rain running off highways and farm land and private drainage being incorrectly connected." (United Utilities)

"In most cases, storm discharges are heavily diluted by rainwater. So, although they're unpleasant, their impact to river water is likely to be minimal. The Environment Agency reports that, overall, they do less damage to the environment than other sources of pollution." (Thames Water)

"In truth, storm overflows account for just 4% of all the reasons for rivers and waterways not achieving the best water quality. As is clear from Environment Agency river quality data, there are many contributing factors outside of water company control that cumulatively have a more significant impact on the health of our waterways." (Anglian Water)

"Combined Sewage Overflows are vital in protecting people from flooding and are widely used across the UK. CSOs are only responsible for 3% of reasons for rivers in England not achieving good ecological status. The water industry accounts for 24% of the remaining quality issues in England's rivers and other sectors, including agriculture, housing and transport, accounting for 76% of the reasons for rivers failing to achieve good ecological status." (Severn Trent)

"Government should work with the water industry, NGOs and others to agree a plan in 2022 to progressively eliminate the four per cent of harm caused by storm overflows to English rivers, starting with the most sensitive catchments." (UK Water)

is less than that of agriculture and that CSOs only make up a small proportion of this contribution to poor status (T9 and T25; see Box 4 for examples). RNAGs were developed before the water industry was required to fit CSO monitors and thus before the full extent of sewage discharges was known. Monitoring has revealed that such discharges are common during periods of no or moderate rainfall in all regions. The lack of accurate data on the extent to which CSOs are discharging, especially the volumes being discharged, undermines confidence in the RNAG system. The water industry continues to take advantage of RNAGs' flaws to play down the impacts of untreated wastewater discharges (T3 and T5; Box 4). Albini et al.[70], in a modelling study of four different rivers, recently concluded that sewage discharge significantly impacts water quality and benthic riverine communities, regardless of the surrounding land uses. Deflecting blame without comprehensive monitoring has delayed regulation and policy change (T19).

The industry has been keen to portray CSO discharges as the result of the public flushing wet wipes down toilets (T9). For example, UK Water in November 2021 stated that "Wet wipe-caused blockages in the sewer are a leading cause of sewage spills from storm overflows"[71]. Southern Water sponsored and organized a 1 day conference entitled the Zero Pollutions Conference in July 2019, in which half the day was dedicated to 'customer engagement influence behaviour' with speakers from South West Water, Anglian Water and Southern Water[72].

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Fig. 2 | An outfall from a CSO on the River Tame in Greater Manchester, UK. Figure reproduced with permission from ref. 25, Springer Nature Limited.

A variety of companies have subsequently run targeted public education initiatives such as 'The Unflushables' (Southern Water), 'Unblocktober' (Thames Water), 'Waging War on Flushable Wipes' (Severn Trent Water), 'Stop the Block' (South West Water) and 'Wipe out Wipes' (Wessex Water). Although wet wipes do combine with fats to create fatbergs, they are a relatively small component of the wider CSO problem (T3, T5, T12 and T25). Others have argued that the main reasons for stormwater overflows are the lack of capacity from increased population and poorly maintained infrastructure such as cracking pipes[66]. The industry arguably encourages such a narrative to mask its complacency and lack of investment (T24). Wet wipes are found in huge numbers in urban river channels and are a particular problem on the bed of the Thames in London. They provide a very graphic illustration of the amount of untreated sewage discharged into England's rivers (Fig. 2).

Event duration monitors have confirmed that such discharges often occur during periods of no or moderate rainfall. A recent chair of England's EA suggested that the threat of closer monitoring caused some WaSCs to acknowledge significant breaches of regulatory permits[73].

UK Water, the body representing the water industry, published an article in 2021 called "The Truth about English Rivers", which was a rebuttal[74] of the criticisms directed at the water industry's performance by campaigners and the media (T22). The article mentioned inaccurate reporting, a distorted and misleading picture and that "commentators are working from the same, shared set of facts about reality on the ground". The article claimed to be the 'truth' and contained many issues addressed in this manuscript relating to misrepresented data. Two years later, in May 2023, Water UK publicly apologised on behalf of the industry, accepting it had not moved fast enough on sewage discharges or infrastructure investment and committed to increased funding plus greater transparency and accountability[75].

One of the inaccuracies is the EA's oft-cited statement that "Water quality in our rivers is now better than at any time since the start of the Industrial Revolution". The water industry and several politicians have widely promoted this statement (for example, Severn Trent, 23 November 2021). This statement was recently reviewed by a team of academics[76], who concluded that the conclusions were, at best, mixed, with pressures from nutrients and pesticides having increased in many areas since the 1940s and diffuse-source pollution and novel pollutants, including microplastics and forever chemicals, increasing in recent decades to pose substantial water quality threats. A recent study of nitrogen isotopes in macroalgae in the Mersey Estuary has shown that sewage pollution is now higher than at any point since privatization[77].

BOX 5

Examples of water industry communications highlighting the cost implications for the public should they try to fix stormwater overflows (CSOs), taken from company web pages, 20 March 2023

"Many storm overflows are decades, if not hundreds of years old, and this legacy infrastructure is an antiquated system for the modern world. Removing them completely would be complicated, disruptive and expensive, with an estimated price tag of £600 billion to effectively re-plumb major towns and cities across the UK." (Anglian Water)

"The cost, both financially and environmentally, to remove all storm overflows would be substantial. It would cost billions and cause major disruption digging up urban and rural areas." (South West Water)

"At Anglian Water, we've been working through them for years, and fixing them where they cause problems. This isn't new and it isn't something that is driven by the recent media or political coverage. It's because we don't think they are fit for purpose and we want any issues with them resolved. We must do this in a prioritised way however, as the engineering solutions are not straightforward and the cost to customers is significant." (Anglian Water)

"The cost of replacing assets like CSOs with new systems and flood mitigation (as properties still have to be protected from flooding) would run into many billions. Customer bills would rise dramatically, not to mention the disruption caused by completely replumbing the major cities in our region." (Anglian Water)

"Building new storage tanks would have significant carbon consequences, cost billions of pounds and would be extremely disruptive – so the best option is to separate surface water from combined sewers. ...It is estimated it would cost around £10 billion to eliminate overflows in our region. To help fund this, customers would see around a 50% increase in bills over 10 years." (Wessex Water)

Northumbrian Water, in their draft drainage management plans, propose four potential options to deal with storm water overflows for customers and stakeholders to consult upon. These four options come with either a predicted 13%, 17%, 34% or 38% rise in bills by 2045, which do not include inflation.

No. 17 in the Goldberg and Vandenberg[6] tactic list is "take advantage of the consumers' lack of money/influence". This tactic is employed in the industry's argument that solving the UK's sewage crisis would cost consumers more than they can afford, even before the problem has been holistically assessed for all interrelated solutions (T17; Box 5). The upper end of the costs predicted to resolve the issue of storm overflows was stated as £660 billion in a report published in 2021 and co-written

by the water industry, the Water Services Regulation Authority, DEFRA and the EA[78]. This value was based on an estimation of digging up every road in the UK with a combined foul and surface water sewer. The water industry and many members of parliament in the serving government also mentioned the excessive cost to the billpayer in response to opposition pressures to reform the industry (T21). Attempts to maintain the status quo through scaring stakeholders over the 'cost of action' have stymied the discussion, investment and legislative reform (Box 5).

Conclusions

In our analysis of England's water industry, we identified 22 (Table 1) of the 28 tactics reported by Goldberg and Vandenberg[6] to deflect blame and diminish responsibility. These 22 tactics broadly map onto the 5 macro-strategies and the 19 meso-strategies proposed under the alternative framework of Legg et al.[5] to compare industry approaches to manufacture doubt and manipulate the use of science in policy and practice. Many of these strategies[5] and/or tactics[6] have been used to control the narrative and reduce, weaken and delay legislation that would place tighter controls on the very water industry activities that keep profitability high. Collectively, they provide evidence of industry approaches to manufacturing doubt that have detrimental effects on both environmental and public health. No river in England has a good overall health status, and only 15% have good ecological health status[24]. The UK government and EU parliament, under Directives 2005/29/EC and 2011/83/EU, have recently put forwards plans to prevent greenwashing by the commercial sector. Buse and Bayliss[12] commented that water companies "…urge consumers to use less water—yet given their own record, this amounts to little more than using the standard corporate playbook of shifting responsibility to users." Giakoumis and Voulvoulis[79] stress that, while the general public can play their part to flush "pee, poo and paper" only, the most important issue to address is the investment in the sewerage infrastructure and that "Consumers are called upon to act in the public interest, while the private equity owners operate in the interests of shareholders." Water companies routinely cite volumes of drinking water consumed, yet they are extremely reluctant to give volume data on the untreated wastewater they discharge to the environment, despite clear demonstrations of the ease of estimating volumes from existing datasets[16]. During cross-examination by the parliamentary EAC in October 2021, several water company bosses conceded that they were unaware of any optimized technologies that could measure volumes and were seeking options globally[78,80]. On the other hand, Thames Water has published discharge volumes for Mogden WWTW (serving 2 million customers) for a decade. Scottish Water estimated that, during 2022, their assets discharged an estimated 47 million cubic meters of wastewater into river and coastal waters[81], suggesting that estimations of volumes were feasible in many UK water company contexts.

Climate change will make water an increasingly valuable commodity globally[82]. The communications and misinformation strategies highlighted in our analysis are important industry tools to deflect criticism and perpetuate the status quo. We propose that industry communications should also be regulated so that any signs of manufactured doubt, misinformation and spin can be challenged. A closing example is provided from an advertising campaign by Anglian Water, which extolled the virtues of the company's wildlife-friendly wetlands. In June 2023, the advertisement was banned and sanctioned by the Advertising Standards Authority[83], who concluded that Anglian Water "…carried out activities that caused harm to the environment, which contradicted the overall impression of the advertisement." We are hopeful that such criticisms in the future will come from the industry regulators themselves and that future pressure will not be reliant on the complaints of 'nine citizens' to correct the messaging of the water industry.

Methods

Several approaches have been employed to examine the tactics/strategies employed by industries to influence science and policy[5,6]. A review of individual water company communications in England from their webpages (Supplementary Table 2) and those of their trade association (UK Water) and ad hoc social media messages was conducted and mapped against the 28 tactics used by the industry to manufacture doubt by Goldberg and Vandenberg[6]. We also conducted a mapping exercise to compare commonalities in the frameworks for strategies proposed by Legg et al.[5] and the tactics proposed by Goldberg and Vandenberg (ref. 6 and Supplementary Table 1). This process highlighted that, at least for the higher (macro- and meso-strategy) strategies proposed by Legg et al.[5], there were considerable overlaps between the two frameworks. This enabled us to discuss, at least in broad terms, the substantive evidence for water industry strategies/tactics for manufacturing doubt. There are many definitions of greenwashing[84], and the one adopted here from Webster's *New Millennium Dictionary of English* (https://www.merriam-webster.com/) is the "practice of promoting environmentally friendly programs to deflect attention from an organisation's environmentally unfriendly or less savoury activities". In addition, the analysis is supported by evidence from sources such as formal responses of leaders within the EA, Ofwat, the OEP, DEFRA, judiciary summary reports from the Department of Justice, transcripts of minutes of cross-party parliamentary committees in England, the EAC, the Environment, Food and Rural Affairs Committee, the water industry, CEOs of water companies and Water UK (the mouthpiece for the water industry).

Each tactic we have mapped is highlighted in the text by the number of the tactic in Table 1 preceded by a 'T' (that is, T1–28). Where it is not mentioned, to the best of our knowledge the water companies have not issued a response to criticisms and accusations.

Data availability

The authors confirm that all data generated or analysed during this study are included in this published article.

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Author contributions

A.T.F. conceived the manuscript. A.T.F., A.C.S., P.H. and J.W. contributed to the researching, writing and editing of the manuscript.

Competing interests

A.T.F. is an academic who has received funding from research councils, the European Union, government agencies, philanthropic organizations and industry, which has included water companies. A.C.S. is an academic who has received funding from research councils, government agencies and industry, which has included the UKWIR. P.H. is a retired mathematician and computer scientist, previously funded as an academic at University College London and the University of Oxford for research unrelated to the water industry. He currently supports a citizen science campaign group called Windrush Against Sewage Pollution. J.W. is a physical geographer who has received funding from the Natural Environment Research Council. He has not received funding from the water industry.

Additional information

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