Common Seas

Plastic Drawdown

A new approach to identify and analyse optimal policy instruments to reduce plastic pollution in UK rivers and seas.

May 2019

Plastic Drawdown
A new approach from Common Seas for addressing plastic pollution.

Plastic Drawdown provides the most detailed and comprehensive assessment of plastic leakage developed to date anywhere in the world. It is a fully developed policy assessment tool that allows governments to rapidly identify key plastic flows and polices to reduce, or 'drawdown', predicted levels of ocean plastic pollution.

Delivered in partnership with Eunomia and supported by Oxford University.

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Executive Summary

This paper presents Plastic Drawdown as a comprehensive and evidence-based tool to support governments in identifying the best policies to mitigate their country's plastic pollution. Plastic Drawdown can also be used to evaluate the potential effectiveness of proposed plans and policies, thereby supporting the process of developing effective strategies to tackle plastic pollution. It helps to develop recommendations for effective action, and indicates where to focus future actions, research and innovation.

To illustrate Plastic Drawdown's role as an evaluation tool, this paper uses a model developed for the UK, which explores the impact of England's Resources and Waste Strategy ("the Strategy") to reduce plastic waste leaking into the UK's rivers and seas. The analysis reviews the measures included in the Strategy and highlights the most effective interventions in terms of the total mass of avoided plastic pollution by 2030 and the overall proportion of the plastic waste flow into the watercourse that is likely to be addressed. A Deposit Return Scheme (DRS) for single-use drinks containers is shown to be the most effective intervention within the Strategy. It has the potential to achieve a 6.6kt 'drawdown' (total avoided plastic emissions by 2030), which constitutes 45% of the total effect of the Strategy. Item taxes and bans make a small contribution in terms of drawdown but are effective in addressing a high proportion of the waste flow for those items targeted. For example, a ban on straws, stirrers and cotton buds has a limited drawdown (of up to 0.47kt) because these items are

low in mass. However, a well enforced ban can effectively remove these items from the market, which means a high proportion of the plastic leakage attributed to these items is addressed (up to 99.4%).

The paper also evaluates the overall effectiveness of the Strategy relative to the total mass of plastic estimated to enter the watercourse from the UK. This highlights several important sources of pollution that are outside the scope of the Strategy but are now understood to be highly significant. Specifically, tyre dust emitted due to vehicle road-wear and the plastic pellets used in production are predicted to make the greatest total contribution to plastic leakage from the UK. Whilst our understanding of these plastic waste flows and the interventions to prevent emissions are less developed – and the small particle size makes capture technically challenging – the paper indicates where further efforts could be targeted. It includes recommendations for research and future policy development to address these key flows into the ocean.

The paper highlights how Plastic Drawdown provides a common framework for decision-making. It gives countries around the world a like-for-like comparison of plastic waste generation and identifies solutions to reduce plastic waste flows into rivers and seas. In turn, this illustrates the need for country or regionally-specific mitigation strategies that respond directly to the characteristics of the local plastic pollution problem. To illustrate this, the paper compares the Plastic Drawdown analysis for the UK with that of Indonesia, contrasting the fact that the focus of policy will increasingly need to be on microplastics in the former, whilst more conventional waste management policies are urgently needed to address the dominant macroplastic flows in the latter.

1.0 Introduction to Plastic Drawdown

Plastic Drawdown is a comprehensive approach for governments to understand plastic waste flows and identify an optimal portfolio of policies that addresses their nation's specific plastic waste and pollution challenge. The objective is to establish evidence-based strategies, which lead to action across the plastics value chain to prevent plastic leaking into rivers and oceans. Plastic Drawdown includes a model of waste flows, policy guidance and a wedges tool that collectively:

- describes a country's plastic waste mass and composition, including the micro- and macro- plastics that most commonly leak, and how these change under a business-as-usual projection to 2030;
- models plastic waste flows to identify leakage characteristics and quantify the mass of plastic entering the watercourse;
- reviews and models the impact of a range of policies[1], providing guidance to support planning, specification and implementation;

[1] Plastic Drawdown models has a default set of 18 core policies, these are largely focussed on actions that can be taken at national level. The model can readily be adapted to include other policies, either those considered at national level, or those which could be implemented at other

- visualises leakage data within an interactive wedges tool that can be used to investigate the impact of different policy strategies (see Figure 3.1).

Wedges approaches have been a useful way of conceptualising complex environmental challenges[2]. In this context, the size and thickness of the wedge reflects the extent to which a given policy reduces the volume of plastic entering a country's rivers and seas. Visualising these 'wedges' can help nations (and regions and cities) to prioritise and sequence actions, and develop strategies. This approach recognises that different powers (competences) may exist at different levels of government. Plastic Drawdown allows governments to rapidly identify both key plastic flows and the best policies to address the problem. It helps them convene key actors, target and build consensus, and develop an action plan for effective interventions.

The tool is based upon a significant body of research, including (amongst others) work underpinning the EU's plastics strategy, the impact assessment of the Single Use Plastics Directive and research on microplastics for the European Commission.[3,4,5]

Plastic Drawdown gives countries around the world a like-for-like comparison of plastic waste generation. This provides a common framework for decision-making and identifying solutions to reduce plastic waste flows into rivers and seas. Plastic Drawdown has been delivered in Indonesia, Greece, the United Kingdom, and is being developed in the Maldives. This straightforward approach to visualising impact of solutions is ready for worldwide application.

2.0 Analysis of England's Resources and Waste Strategy

England's Resources and Waste Strategy ("the Strategy") sets out how the government is aiming to preserve material resources by minimising waste, promoting resource efficiency and moving towards a circular economy in England. It sets out the plan to double resource productivity and eliminate

levels of government, such as regions, or municipalities (to which the model can equally be applied, albeit with some limitations around data quality).

[2] Analogous to 'climate stabilization wedges', an approach to conceptualise climate change mitigation scenarios by Princeton University researchers S. Pacala and R. H. Socolow

[3] Eunomia Research & Consulting (2018) *Reuse, recycling and marine litter – Impact assessment of measures to reduce litter from single use plastics*, Report for DG Environment, 2018

[4] Eunomia Research & Consulting (2018) *Plastics: Reuse, recycling and marine litter – Impact assessment of measures to reduce litter from single use plastics*, Report for DG Environment, 2018, http://ec.europa.eu/environment/waste/pdf/Study_sups.pdf

[5] Eunomia Research & Consulting (2018) *Investigating options for reducing releases in the aquatic environment of microplastics emitted by (but not intentionally added in) products*, Report for European Commission, February 2018

avoidable waste of all kinds (including plastic waste) by 2050.[6] The Strategy sets out how the government aims to:

- preserve England's stock of material resources by minimising waste, promoting resource efficiency and moving towards a circular economy;
- minimise the damage caused to the natural environment by reducing and managing waste safely and carefully;
- deal with waste crime.

The Strategy combines short term actions with a range of commitments for the coming years and sets out the longer-term policy direction in line with the government's 25 Year Environment Plan, which includes:

> *"Significantly reducing and where possible preventing all kinds of marine plastic pollution – in particular material that came originally from land."*

The objective of this paper is to understand the implications of the Strategy for leakage of plastics into the marine environment from the UK, using the Plastic Drawdown wedges tool for the UK, which was developed in advance of the Strategy's release. The approach taken by Plastic Drawdown and the baseline flows for the UK are presented in the Annex. For this analysis, the interventions proposed in the Strategy were modelled, with the parameters used in the model to drive the effects of policy chosen to reflect central, optimistic and pessimistic cases. The impact, in terms of overall reduction in the flow of plastics into the watercourse, was set to be highest in the optimistic case, and lowest in the pessimistic case, with the central case lying between the two.

The interventions, as they appear in the Strategy, are described in Table 2.1. Within the model, the parameters for these interventions were chosen to reflect the strength of commitment to a given policy, as it is set out in the Strategy. For example, the effect of a given policy to which a firm commitment has been made by government was deemed likely to be closer to the 'maximum potential' in the optimistic scenario than where the commitment to change appears weaker. Indeed, if there is not full commitment to a given policy in the Strategy, then under the pessimistic case, it is assumed not to enter into force, and hence, no effect is assumed. These factors were set based upon the research that underpinned the wedges model itself, and the expertise of the project team. Please note, the modelled measures relate to UK flows, whereas some of the measures in the Strategy are proposed only for England. We recognise that devolved administrations are likely to implement their own specific measures that may have different impacts. Indeed, the recent announcement by the Scottish Government to implement a deposit refund scheme - albeit the scheme has not yet been fully designed - is one example of this.[7]

[6] Defra, Environment Agency (2018) *Resources and Waste Strategy for England*, https://www.gov.uk/government/publications/resources-and-waste-strategy-for-england
[7] See https://www.gov.scot/policies/managing-waste/deposit-return-scheme/

Table 2-1 Summary Description of Relevant Measures in the Strategy

Intervention	Description
Tax on recycled content + increased carrier bag charge	Stimulate demand for recycled plastic by introducing a tax on plastic packaging with less than 30% recycled plastic content. Consult on increasing the existing 5p carrier bag charge and extending it to all retailers on a mandatory basis.
More water refill points	Supporting consumer campaigns to promote reusable alternatives, such as encouraging water companies and retailers to provide more free public refill points.
Bans on straws, stirrers and cotton buds	Ban plastic products where there is a clear case for a ban and alternatives exist (plastic straws, drinks stirrers and cotton buds will be banned from sale and use in England from April 2020).
Deposit return scheme (DRS) for single-use drinks containers	Introduce a DRS in England for single-use drinks containers, subject to consultation.
Improvement of solid waste collection and recycling services	Implement a range of targets for the recycling of municipal waste (minimum 65% by 2035) and packaging waste (matching or exceeding the revised packaging recycling targets set by the EU for 2025 and 2030) and waste sent to landfill (maximum 10% by 2035). Review and consult on Extended Producers Responsibility for a range of materials (including packaging, textiles, fishing gear, tyres, bulky waste, construction & demolition waste) to ensure producers pay the full net costs of managing packaging waste at end of life. Other supporting measures including, for example, consultation on minimum service standards and performance indicators, digital recording of waste movements.
Litter (including improper disposal of waste by flushing) and fly-tipping regulations	Create a 'fly-tipping toolkit', a web-based tool hosted by the National Fly-tipping Prevention Group to help tackle the issue. Award up to five companies a maximum of £80,000 to further develop their ideas on smart tracking of waste through the economy. Consult on and reform regulations for duty of care, carrier/broker/dealers, waste exemptions, hazardous waste,

Intervention	Description
	and international waste shipments (for example, by digital recording of waste movements). Support the water industry's ongoing work to ensure any wipes marked as 'flushable' are plastic-free and truly flushable.
Policies related to reducing microplastic release from clothing	By the end of 2025, review and consult on measures such as EPR and product standards for textiles, including at least all clothing, as well as other household and commercial textiles such as bed linens. Develop policy proposals to reduce the environmental impacts of clothing, including the impacts of microplastics in the water system. It has been assumed that the interventions in the wedges model related to fibre release thresholds are reflective of the type of measure these commitments would include.
Measures such as EPR and product standards for fishing gear	By the end of 2025, review and consult on measures such as EPR and product standards for fishing gear, ensuring that any new requirements do not create a competitive disadvantage for fishing industry. It has been assumed that the interventions in the wedges model related to fishing gear are reflective of the type of measure this commitment would include, for example collection systems though EPR and deposit refunds for fishing gear, including track & trace systems.

The key outputs from the modelling of the interventions in the Strategy are outlined below. The total drawdown in the optimistic scenario is approximately 15kt. Table 2-2 shows the predicted drawdown effect of each intervention. Note that the effect is shown in terms of the reduction by weight of plastics flowing into the rivers and seas. It should be considered that weight might not be the best indicator of the harm caused by different items escaping into rivers and seas. Nonetheless, by this measure, the most effective intervention, as indicated by weight reduction, is DRS for single-use drinks containers which, in the optimistic scenario, could prevent as much as 6.6kt of plastic from entering the sea by 2030, making up 45% of the total effect of the Strategy. The optimistic scenario assumes the measure is not restricted to beverage containers below a specific size. In contrast, additional taxes on plastic bags, and bans on items like straws and stirrers give rise to relatively small effects in terms of the mass of plastics prevented from entering the watercourse. However, these measures are more significant when the policies are considered in terms of the number of plastic items prevented from entering the watercourse (as shown in Figure 2-2). Revenue from taxes and the enforcement of bans can also used to fund wider mitigation efforts.

Interventions relating to recycling, in and of themselves, do not have a large effect on the leakage of plastics into the marine environment. Increasing recycling reduces residual waste arisings, which means less plastic waste going to waste treatment and disposal facilities, such as landfills, where leakage into the environment can occur. However, in the UK context, the losses from landfills and incineration plants are considered likely to be relatively small.[8] Consequently, measures related to improved recycling collections are only predicted to have a small effect on plastic leakage. Recycling, of course, delivers many other benefits, particularly related to mitigation of climate change.

Table 2-2 Summary of drawdown (kt of avoided plastic emissions by 2030) for each intervention within the Strategy under each scenario

Strategy Intervention	Drawdown by scenario			% Total
	Pessimistic	Central	Optimistic	Optimistic
Deposit return scheme for single-use drinks containers	0.20	2.35	6.66	45%
Policies related to reducing microplastic release from clothing	0.00	1.19	2.38	16%
Litter (including improper disposal of waste by flushing) and fly-tipping regulations	0.00	1.28	2.35	16%
Measures such as EPR and product standards for fishing gear	0.00	1.26	1.78	12%
More water refill points	0.00	0.51	0.55	4%
Bans on straws, stirrers and cotton buds	0.04	0.44	0.47	3%
Improvement of solid waste collection and recycling services	0.35	0.37	0.42	2%
Tax on recycled content + increased carrier bag charge	0.15	0.23	0.30	2%
Total Drawdown (kt)	**0.81**	**7.63**	**14.84**	**100%**

This effectiveness of the interventions in the Strategy in addressing different sources of plastic pollution within the scope of the Strategy is further explored in Figure 2.1. In the Optimistic Case, bans are very effective in terms of reducing the flows of the specific waste stream that is addressed by the ban.

[8] There are concerns regarding the loss of plastics from older, now-closed, landfill sites, specifically those close on the coast, where sea-level rise is leading to a significant risk of losses as a result of coastal erosion (which can expose the body of the landfill directly to the sea) (see James H. Brand, Kate L. Spencer, Francis T. O'Shea and John E. Lindsay (2017) *Potential pollution risks of historic landfills on low-lying coasts and estuaries*, https://onlinelibrary.wiley.com/doi/full/10.1002/wat2.1264 .

For example, in the optimistic scenario, bans on straws and stirrers contribute 99.4% of the total drawdown achieved for these items.

Similarly, 96.5% of the drawdown achieved with regards to plastic bags is attributable to the measures proposed to extend taxation on grocery bags (taxes based on recycled content, increasing the existing 5p carrier bag charge and extending it to all retailers).

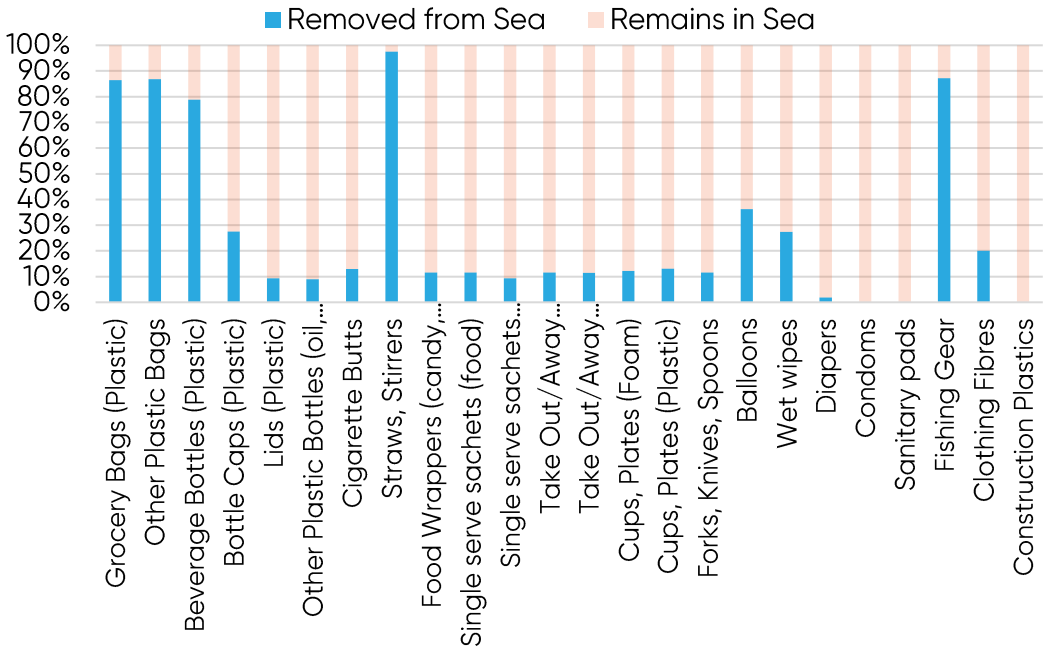
The measures proposed to address plastic waste from fishing gear entering the ocean have the potential to be highly effective both in terms of drawdown, and the proportion of the flow that is addressed (1.78kt of avoided pollution by 2030, which is equivalent to 87% of the total flow of plastic waste attributed to fishing gear).

In contrast, whilst in absolute terms interventions to address microfibres are potentially significant (2.38kt drawdown in the optimistic scenario), this only addresses approximately 20% of the estimated total emissions into the watercourse. This is because of the high shedding rates from clothing and other textiles, and the less developed solutions to prevent fibre release or intercept fibres that are released (discussed in Section 4.0 of this report).

Leakage of on-the-go waste (like sachets, wrappers and take out containers) and construction plastics is only addressed through a general requirement on addressing litter and fly-tipping, and as such the effect is also limited, although the absolute number of some items, such as those related to construction plastics, is estimated to be small.

Further strengthening of litter policies and labelling of non-flushables are expected to have a combined effect on tackling littering of some items. However, wet wipes are not tackled in a robust way under the Strategy, and basic labelling requirements are considered unlikely to have a substantial impact, with only a 27% reduction in the flow of wet wipes in the optimistic scenario. This is important because a large proportion of wet wipes enter the sea through storm water overflow events.

Figure 2-1: Proportion of annual flow of each item removed from the sea under the Strategy (Optimistic Case)



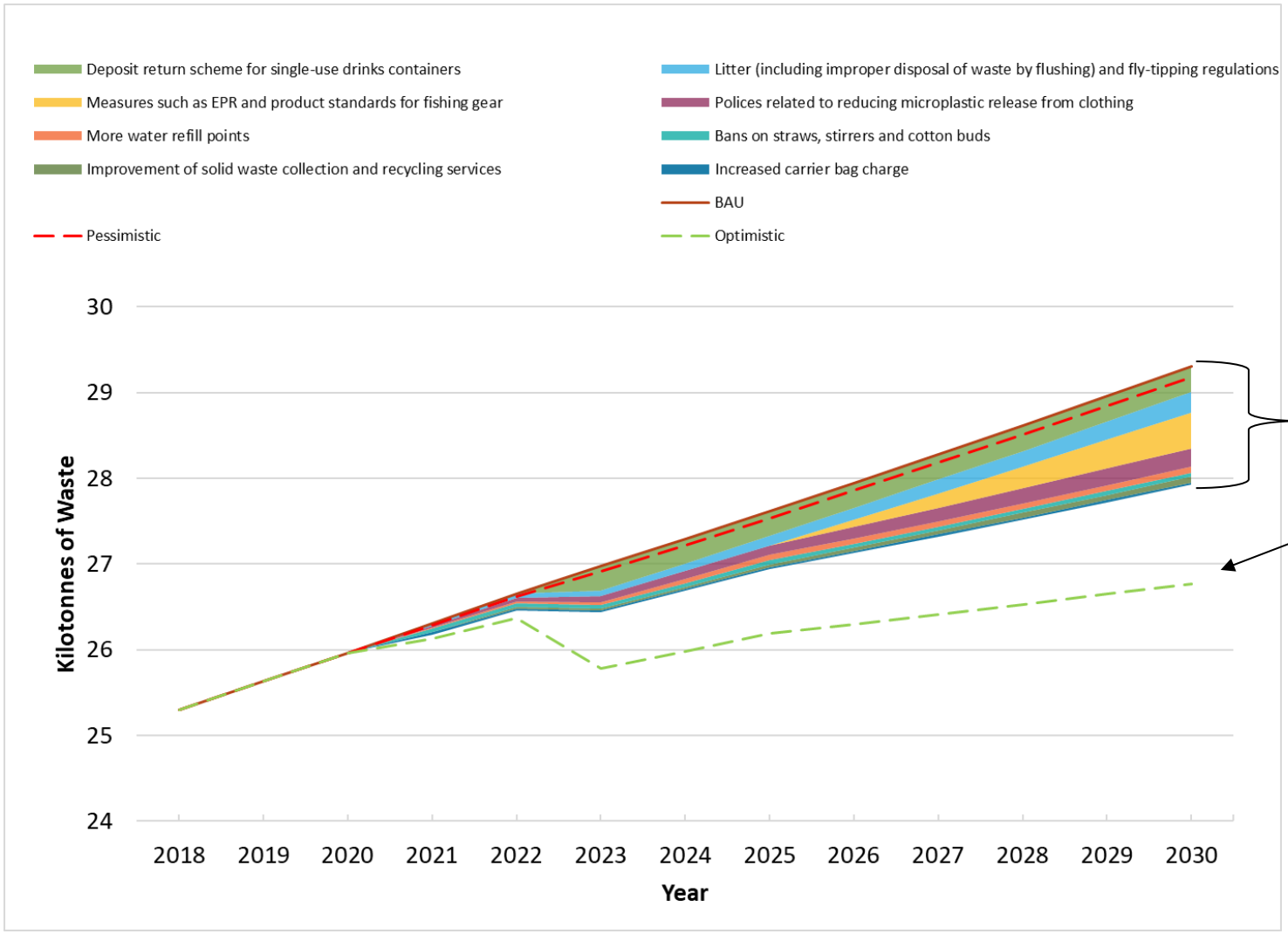
3.0 Achieving Optimistic Drawdown

The 'wedges' graph in Figure 3-1 shows the year-on-year contributions made by each intervention to the overall drawdown achieved. Each intervention is shown as a different coloured band (or 'wedge'), with some interventions predicted to start sooner, in accordance with timeframes described in the Strategy. Additionally, some interventions are predicted to take longer to deliver full effects, e.g. DRS is considered to have the potential to reach its maximum effect on plastic flows faster than the more complex range of measures proposed to address fishing gear, which are expected to come into effect more gradually.

The difference between the total drawdown achievable in the central scenario and the other scenarios is indicated by the red dashed line (pessimistic scenario) and green dashed line (optimistic scenario). Whilst the total drawdown achievable between 2020 and 2030 is approximately 15kt in the optimistic scenario, it is 8kt in the central scenario and only 1kt in the pessimistic scenario. This reflects considerable uncertainty about the way in which many of the measures announced within the Strategy will be taken forward and implemented.

In order to achieve the optimistic level of drawdown, the government will have to take clear steps to ensure that interventions proposed are clearly specified and effectively delivered and enforced so as to address a broad scope of the targeted items. The pessimistic scenario assumes that an absence of clear commitment within the Strategy means many interventions may not come into effect at all, whereas the optimistic scenario assumes that interventions are well designed and implemented.

Figure 3-1: Wedges chart showing the year effect of each intervention in the Central Scenario (with dashed lines indicating the cumulative effects of the Pessimistic and Optimistic Scenarios)



Coloured wedges indicate the drawdown for each intervention within the Central Scenario

The green dashed line indicates the total level of drawdown achievable within the optimistic scenario. To achieve this, interventions must be effectively specified and delivered

Plastic Drawdown includes a policy analysis that is used to draw out specific recommendations for how the optimistic scenario can be achieved. For example, the central scenario for DRS relates to the case where an 'on-the-go' system only is installed, which is expected to limit the overall impact on littering and recycling rates. To achieve the optimistic scenario the government would have to ensure that all beverage containers, not just those under a certain volume threshold, were included in the DRS. The deposit should be set at a high enough level to stimulate behaviour (e.g. 20p was proposed in Scotland), and the return infrastructure should be made convenient so as to incentivise a high rate of return.

Whilst the interventions proposed to address fishing gear are potentially significant, there is little clarity on what the actual measures will be. Moreover, the level of enforcement of such measures could vary considerably given the challenges in enforcing policies related to dispersed fleets of fishing vessels. To achieve an optimistic outcome, EPR for fishing gear should be comprehensive and cover all costs of collecting, recycling, preparation for reuse or discarding of end-of-life fishing and aquaculture gear. It would also mandate, and include, funding for training for fishermen in best practice in prevention of abandoned, lost and discarded fishing gear (ALDFG) and waste management (this is equivalent to industry paying for public awareness around litter within EPR for packaging). Additionally, it would mandate and include funding for the implementation of gear removal programmes. A requirement to use GPS technology on the broadest range of fishing gear possible should be implemented, which would facilitate logging and reporting of gear loss on a centralised system. Increased efforts to find lost gear and full enforcement of infringement of reporting requirements should be made.

Zoning of fishing areas could be implemented to restrict use within an area to avoid gear conflict and intentional loss. Several methodologies could be used here, looking at restrictions to certain types of fishing, particular times of year (aligned to species breeding season), and on non-registered vessels.

Finally, a '100% no special fee system' system should be installed. This means, as a general rule, that vessels pay a set fee (or 'indirect fee') for waste management regardless of quantity delivered. Such a system means they are not financially incentivised to dump at sea, the size of the incentive increasing in direct proportion to the amount of waste, as would happen for waste delivery charged by the unit. In a similar way, vessels, under the no special fee system, are not actively incentivised to discard waste they have caught by accident, that is not theirs, at sea.

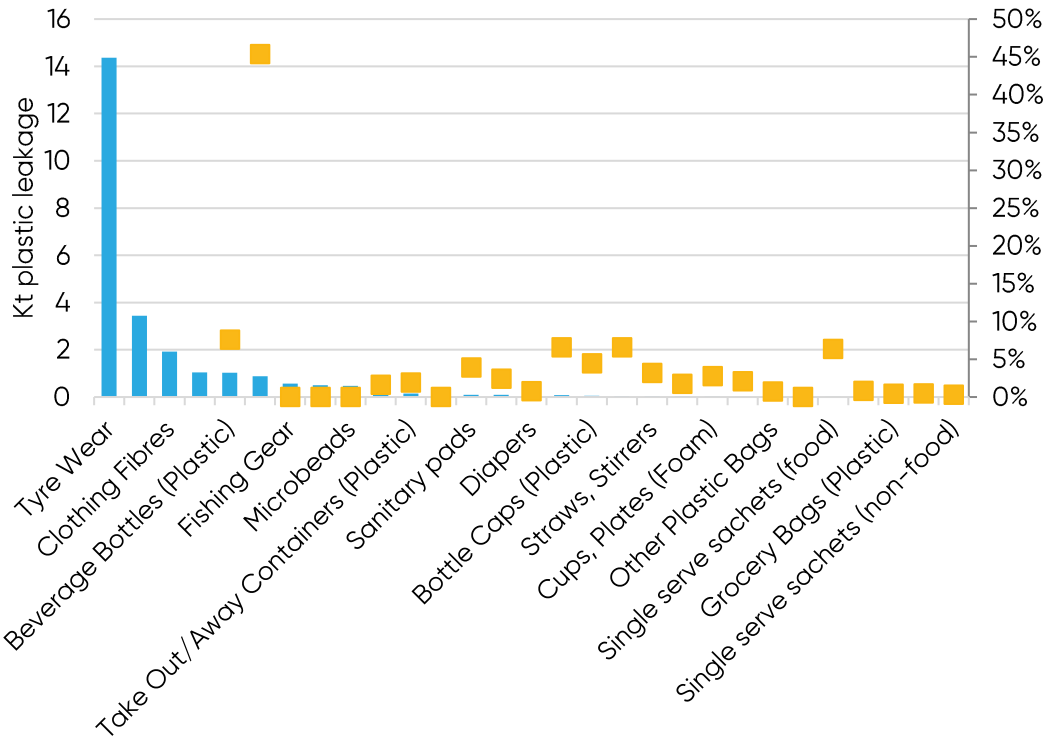
In the case of microfibre release, to deliver an optimistic scenario the proposed EPR schemes should consider how determining a fibre release range could help create a threshold that removes the worst performing textiles products from sale. This would necessitate the comparison of fabrics placed on the market for their tendency to release fibres during washing through standardised testing methods. A good quality standard could then be put in place with appropriate enforcement measures, as well as consumer campaigns on how to minimise shedding rates (e.g. through washing temperature and detergent use).

4.0 Identifying Future Priorities

Plastic Drawdown can be used to investigate the significance of plastic waste flows that are beyond the scope of the Strategy as it stands, and to make recommendations to focus future policy development, research and innovation. Plastic Drawdown models the total flow of plastic waste that enters the watercourse from the UK, which includes 29 different micro and macro plastics. These items have been identified based on what is most commonly found in the marine environment.[9]

Figure 4-1 shows the baseline of plastic waste entering the sea (kt/annum) across 29 of the problem plastics within Plastic Drawdown. Based on the best data available today, the largest emission of plastics into the watercourse come from the abrasion of vehicle tyres on the UK's roads. Another key plastic pollutant is plastic pellets, which are the basis for plastic production and can spill during transportation or be swept into drains in loading bays or plastic production facilities.

Figure 4-1: Baseline waste entering the watercourse across all items within Plastic Drawdown, kt per annum



[9] Plastic Drawdown includes the top 95% of items by count from beach litter surveys for target countries and additional items of concern that may not be identifiable in such surveys

Figure 4-2 looks at the remaining plastic flows into the ocean, across the same items, once the Strategy has been delivered within the optimistic scenario.

The impact of the Strategy is zero, or small, for both tyre dust and plastic pellets. Whilst the Strategy mentions a potential review of measures related to extended producer responsibility (EPR) on tyres, it is unclear whether this would extend beyond a requirement to fund the collection and recycling, and hence, whether loss of microplastics would be addressed. Hence, it has been assumed that tyre dust would not be addressed at all in the Strategy. Consequently, the levels of leakage of plastics into the marine environment is assumed to remain as per business as usual following the introduction of the Strategy.

Figure 4-2: Post-intervention composition of plastic waste entering the sea

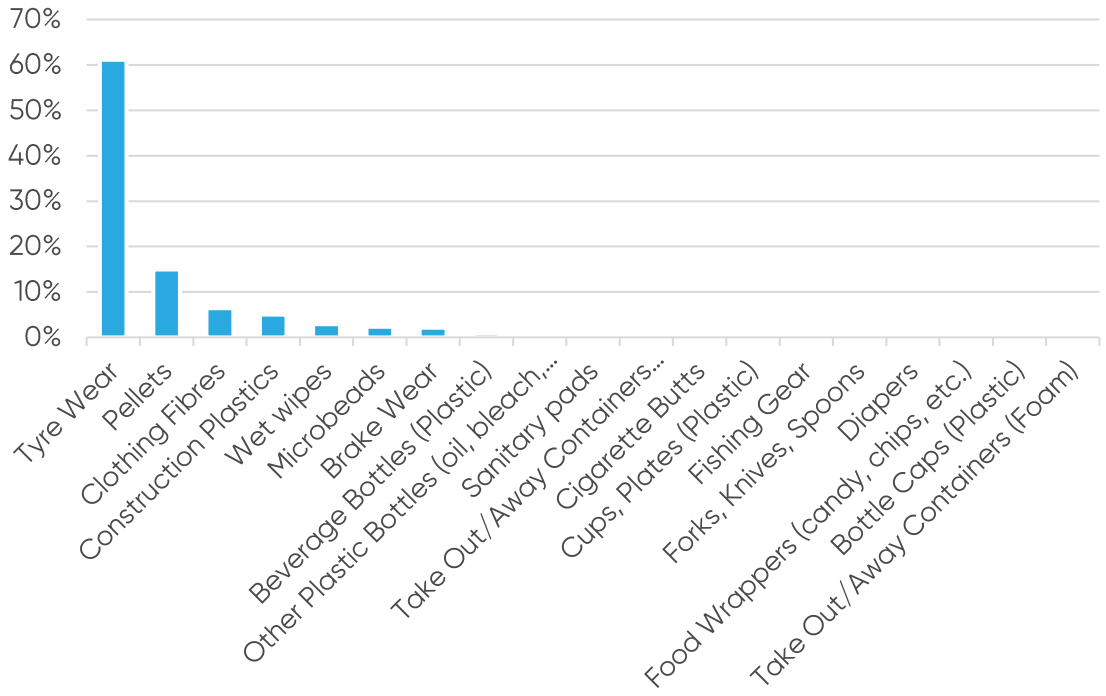
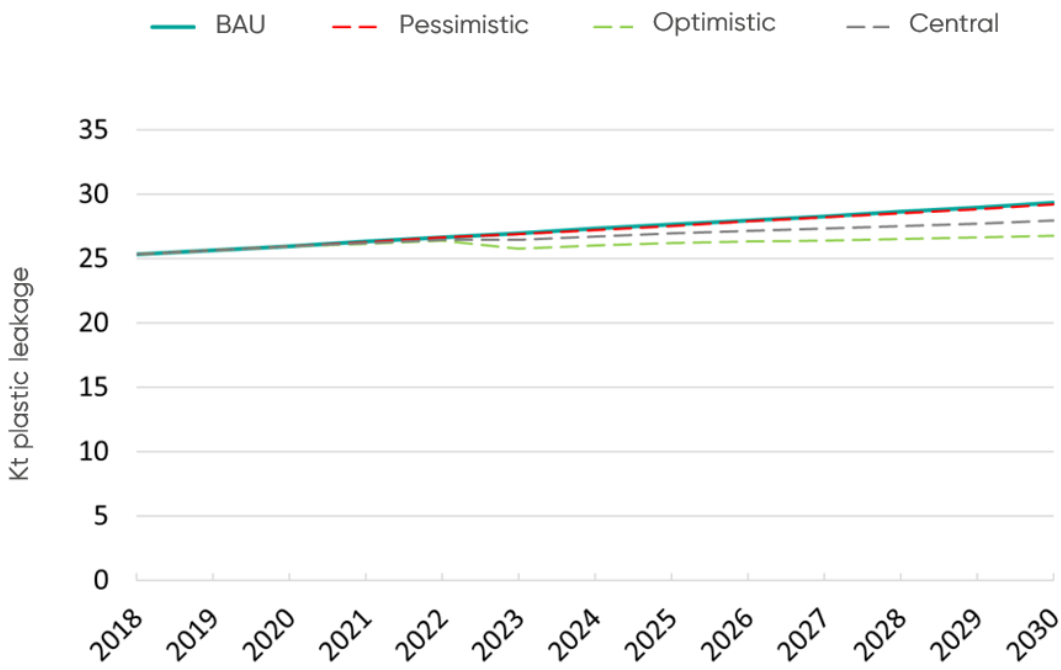


Figure 4-3 shows the overall effect of the Strategy for each scenario, relative to the business as usual projection of total plastic waste flows for the UK. Once the full range of plastic pollutants is considered, the reduction in the amount entering the sea as a result of the Strategy is only a small proportion of projected business-as-usual emissions. Under the central case this represents only 2.5% (8kt) of the total leakage of plastics into the marine environment between 2020 and 2030. Even the optimistic scenario, however, delivers only a 5% (15kt) reduction, with the pessimistic scenario delivering a barely discernible 0.3% (1kt) reduction.

Figure 4-3: Overall effect of the strategy



This small impact is driven significantly by the challenges in preventing the flows of microplastic pollution into the watercourse. Microplastics, such as those generated from the wear of tyres and textiles, are emitted in high volumes and their small size makes them hard to manage. Furthermore, there are currently no alternatives that would eliminate tyre dust through in-use wear other than through modal shifts and reduced use of transport. Similarly, stopping clothing fibre release is not practically possible, and preventing them from entering the sea through the sewerage system is challenging.

For plastic pellets, losses from manufacturing facilities have not been adequately tackled by voluntary industry measures. However, principles from such initiatives (e.g. Operation Clean Sweep) could form a starting point for public policy development to address this flow.

The considerations above clearly highlight the need for additional actions to tackle the remaining leakage of plastics into the marine environment not currently addressed by the Strategy. Suggestions for further action, which might be considered in any revisions to the Strategy, are presented in Table 4-1. Additionally, future research should look in more detail at the pathways of tyre dust in the natural environment to determine the fundamental dynamics and key sinks.

Table 4-1: Possible approaches to address remaining leakage of plastics into the marine environment

Item	Possible Approaches
Tyre Wear	Development of a Standard Measure of Tyre Tread Abrasion Rate followed by Inclusion of Tyre Tread Abrasion Rates on the Tyre Label, plus using Type Approval Regulation to restrict the worst performing tyres (in respect of tyre tread abrasion) from the market.
Pellets	Introduce the supply chain accreditation approach, requiring those placing plastic on the market (starting with those placing the greatest amount on the market) to ensure their whole supply chain has implemented best practice in pellet-loss prevention and capture techniques.
Clothing Fibres	Research and innovation into filters for washing machines. In addition, labelling products with a rating for fibre release potential and directions on washing could give consumers a clear choice in the clothing they purchase and could support a shift in consumer preference towards lower shedding materials.
Construction Plastics	Mandatory implementation of site waste management plans, or at the very minimum, a site litter management plan to help restrict blow off of plastics from the construction site or sweeping of plastic offcuts into drains.
Wet Wipes	Wet wipes are a relatively new product and have generally replaced reusable products with those of a single-use nature. The most compelling strategy to tackle wet wipes is to either ban certain types from the market, or apply charges, or taxes, at significant enough levels to result in a reduction in demand. Linked with a strong communication campaign, consumers would be assumed to switch back to reusable alternatives, such as cloth handkerchiefs, cleaning cloths etc, which many householders already own. Alternatively, single-use paper or cotton pads could be considered for use instead of wet wipes in cosmetic applications. In addition, companies selling wet wipes could be made to pay for the costs of dealing with cleaning up wet wipes if they have entered watercourses, or fund infrastructure to screen them out at combined sewer overflows. However, given the number of wet wipes across the UK sewerage system, the costs are likely to be significant. Wet wipes are associated with the vast majority of sewer blockages, so ensuring producers pay for the cost of clean-up would also be important.

Item	Possible Approaches
Microbeads	Microbeads are mostly released into the environment by being washed down drains at home and passing through wastewater treatment works (over and above rinse-off cosmetics, in which microbeads are now banned). This is a difficult flow to address. However, manufacturers of microbeads, along with other manufacturers of products that produce microplastics that enter the sewerage system, could be obligated to pay for tertiary wastewater treatment systems, which filter out micro-particles in the effluent. Given the volumes of water leaving these plants, the technology is likely to be expensive. Hence, it may be appropriate to target this at the larger facilities across the country to benefit from economies of scale.
Brake Wear	Some particles from brake wear will enter the sewerage system from roads if the drains enter a combined sewer. The above indicated above for microbeads could equally be applied here. For particles entering surface water drains that discharge directly to watercourses, the potential for a currently known solution looks limited. Further R&D in this area is required. Regenerative braking may also be beneficial because engine braking can reduce wear on the pads.
Other Littered Items	Fully funded and resourced street cleaning / beach clean-up as proposed by the European Commission's Single Use Plastics Directive.

There are two additional flows of plastic waste not captured in the figures above that are of interest. These are:

1. Waste, other than fishing gear, discarded directly into seas and rivers by water-borne vessels; and
2. Waste exported from the UK for recycling, notably to South and South East Asia (SEA).

The first of these is not mentioned in the Strategy but has been the subject of a proposal under the Port Reception Facility Directive. This revision aims to achieve a higher level of protection of the marine environment by reducing waste discharges at sea, as well as improved efficiency of maritime operations in port by reducing administrative burden and by updating the regulatory framework.

The issue of waste exports is important because the general waste management situation in many countries receiving this waste is poor, leading to a potential for plastic to be blown out of recycling facilities, intentionally dumped or blown/washed from landfills if the material is not fit for recycling and sent for disposal. In 2018, around 650 thousand tonnes of plastic waste

was exported from the UK.[10] The WRAP packflow report suggests 80% is being exported outside of the EU, where the likelihood of waste being mismanaged is highest.[11] This was before the China import ban (Operation Sword), and a more recent assessment suggests 28% is going to Malaysia and Indonesia.[12] Whilst it is difficult to identify a precise figure, it is assumed, perhaps conservatively, that 35% of exported waste is going to countries where a significant proportion of it could be mismanaged. It is difficult to make a credible estimate of the total amount of plastic entering the sea from UK exports (many are trying to make such estimates but we attach extremely low levels of confidence to those estimates), but using estimates of leakage of imported plastics into the marine environment from the Indonesian model, it is not impossible that the figure could lead to something approaching a doubling of the total amount of plastic we estimate to be flowing into the sea from UK sources, as much as several thousand tonnes per annum.

Whatever the exact magnitude of the figure, it is critical for the UK government to consider measures that encourage recycling of material in the UK, where the use of recycled content remains at relatively low levels. Furthermore, the European Waste Framework Directive already states, in Article 11a (8), that Member States must apply the following rule when calculating the amount of their waste that is recycled.

> *"8. Waste exported from the Union for preparing for re-use or recycling shall count towards the attainment of the targets laid down in Article 11(2) and (3) of this Directive by the Member State in which it was collected only if the requirements of paragraph 3 of this Article are met and if, in accordance with Regulation (EC) No 1013/2006, the exporter can prove that the shipment of waste complies with the requirements of that Regulation and that the treatment of waste outside the Union took place in conditions that are* ***broadly equivalent to the requirements of the relevant Union environmental law."***[13] *(emphasis added)*

In other words, countries exporting waste for recycling outside of the European Union must ensure it is recycled under 'broadly equivalent conditions' to those found in the EU. It seems likely this measure has not been properly implemented and enforced, and indeed, a range of measures to address this issue have been set out in the recently closed Defra Consultation on Extended Producer Responsibility for packaging.

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[10] National Packaging Waste Database (2019) *2018 Q1, Q2 & Q3 & Q4 Packaging Recycling & Recovery Data (published 29 March 2019)*, https://npwd.environment-agency.gov.uk/Public/PublicSummaryData.aspx
[11] WRAP (2016) *Plastics Market Situation Report*, http://www.wrap.org.uk/sites/files/wrap/Plastics_Market_Situation_Report.pdf
[12] Packaging News (2019) *MPs call for 'Plastic Packaging Plan' to stop waste exports and create green jobs*, https://www.packagingnews.co.uk/top-story/mps-call-new-plastic-packaging-plan-stop-exports-create-green-jobs-12-02-2019
[13] European Parliament and the Council of the European Union (2018) Directive (EU) 2018/851 of the European Parliament and of the Council of 30 May 2018 amending Directive 2008/98/EC on Waste, 2018/851

It should also be noted that During the Basel Conference of the Parties from 29 April to 10 May 2019, Governments amended the Basel Convention to include plastic waste in a legally-binding framework which will make global trade in plastic waste more transparent and better regulated, whilst also ensuring that its management is safer for human health and the environment[14].

5.0 Comparison with Indonesia

It is also important – and recognised in Defra's Waste and Resources Strategy - that the UK supports (for example, through development assistance) countries with lower quality waste management systems to make significant improvements as quickly as possible, in order to stem the leakage of plastics into the marine environment. The UK's commitments to members of the Commonwealth and to the Global Plastic Action Partnership (GPAP) would be one example of how this support could proceed. An understanding of the key policies that would have the most effect is therefore important.

The benefit of the Plastic Drawdown wedges model is that is can be applied to any individual country, once the necessary data have been sourced and introduced in the model. For countries with a low level of waste management infrastructure, consumer awareness and enforcement, the level of leakage of plastics into the marine environment is generally accepted to be significantly higher than in countries with a convenient and relatively well-funded service for collecting waste from households, such as the UK.

A similar approach to that taken for the UK was adopted in applying our model to the case of Indonesia, a priority GPAP country. No specific strategy was modelled: instead, the model was used to gauge the potential impact of specific policies on the baseline flow of plastics into the rivers and oceans. This provides an example of how the model can help support discussions regarding the possible solutions to the problem of plastic pollution, which is recognised as being especially acute in Indonesia.

The estimates of plastic waste generation for each item are somewhat less certain than for the UK due to the data sources being less readily available, and the data being of (even) more questionable quality.[15] Most researchers studying waste flows in Indonesia accept that the data are limited and of questionable quality. However, we are of the view that the accuracy of the data does not limit the potential for developing clear plans and policies aimed at tackling the problem, which is evident from the amounts of plastic visible in and around Indonesia. Waiting for accurate estimates of the flows is

[14] http://www.basel.int/Implementation/Plasticwastes/Overview/tabid/6068/Default.aspx

[15] It will not need pointing out to anyone well-versed in the UK situation that the quality of the available data for anything other than local authority collected waste in the UK is, to put it politely, 'not good'. The same is true (and the situation is occasionally worse) in many EU Member States: data on waste remain of terrible quality in the vast majority of the world's countries and in our considerable experience, can rarely be taken at face value.

likely to result in delays to policy implementation and meaningful action, and potentially, to millions more tonnes of plastics entering the sea. In short, we know enough to make plausible estimates of the baseline flows, recognising they are unlikely to be a perfectly accurate reflection of the true situation, and hence, to highlight the likely order of magnitude of the effect of different policy interventions. The next phase of work is to strengthen the data gathered via desk research through working with Indonesian stakeholders.

Information was gathered from a variety of sources to populate the model. The baseline flows are outlined in Figure 5-1. The estimate of the quantity of 'other plastics' entering the sea (as depicted in the graphic) is a source of considerable uncertainty, and exerts a significant influence on the total amount of waste entering the sea. A number of studies have been, and are being, undertaken with a focus on quantifying the flows of this mismanaged waste into the rivers and oceans. Deriving national figures for this is not straightforward, least of all where the data available regarding basic figures on waste generation are of poor quality. The large scale of this 'other' category is also difficult to render consistent with the fact that the model develops estimates of flows associated with a range of specific items, so that the 'other' category ought to represent flows of those plastic items not reflected elsewhere in the model. The size of the 'other' fraction could only be rationalised if there are major contributions to plastic flows coming from items which are not widely reported as being found in rivers and seas (which are modelled separately): this seems somewhat contradictory.[16] The accuracy of the estimates of waste arising from specific items would, though, also influence the size of the 'other' fraction. Hence, the size of this 'other' fraction should, in our view, carry a health warning. That said, the total estimated leakage of plastics into the marine environment from the wedges model is just above the top end of the range forecast by Jambeck et al., which reflected only wastes generated within 50km of rivers and seas.

[16] It is, on the other hand, recognised that some items - such as flip-flops - are not included in the above.

Figure 5-1: Baseline waste entering the sea – 2010 to 2030

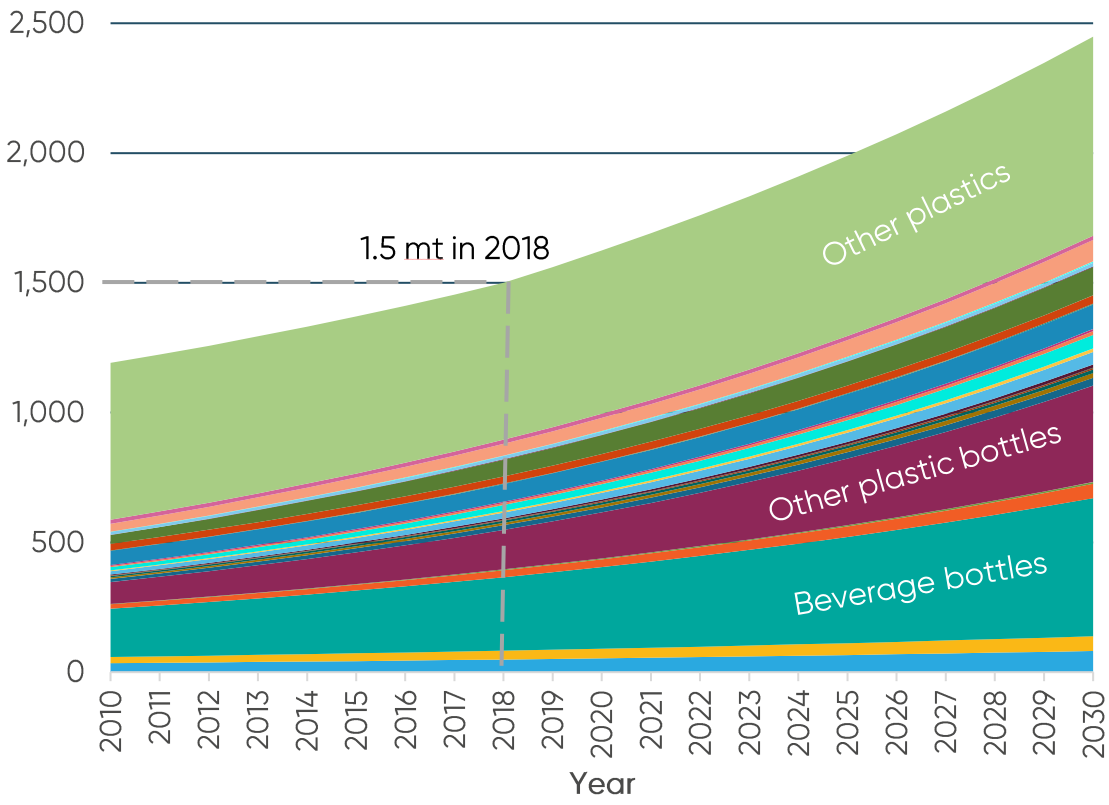


Figure 5-2 shows the wedges chart, which demonstrates the business as usual leakage of plastics into the marine environment increasing to just under 2.5 million tonnes of plastic per annum. The input parameters, in terms of policy effectiveness and timings, reflect what is deemed to be plausible based on the project team's expertise. With the interventions set in the model, the overall plastic leakage may be reduced to around one tenth of this figure by 2030.

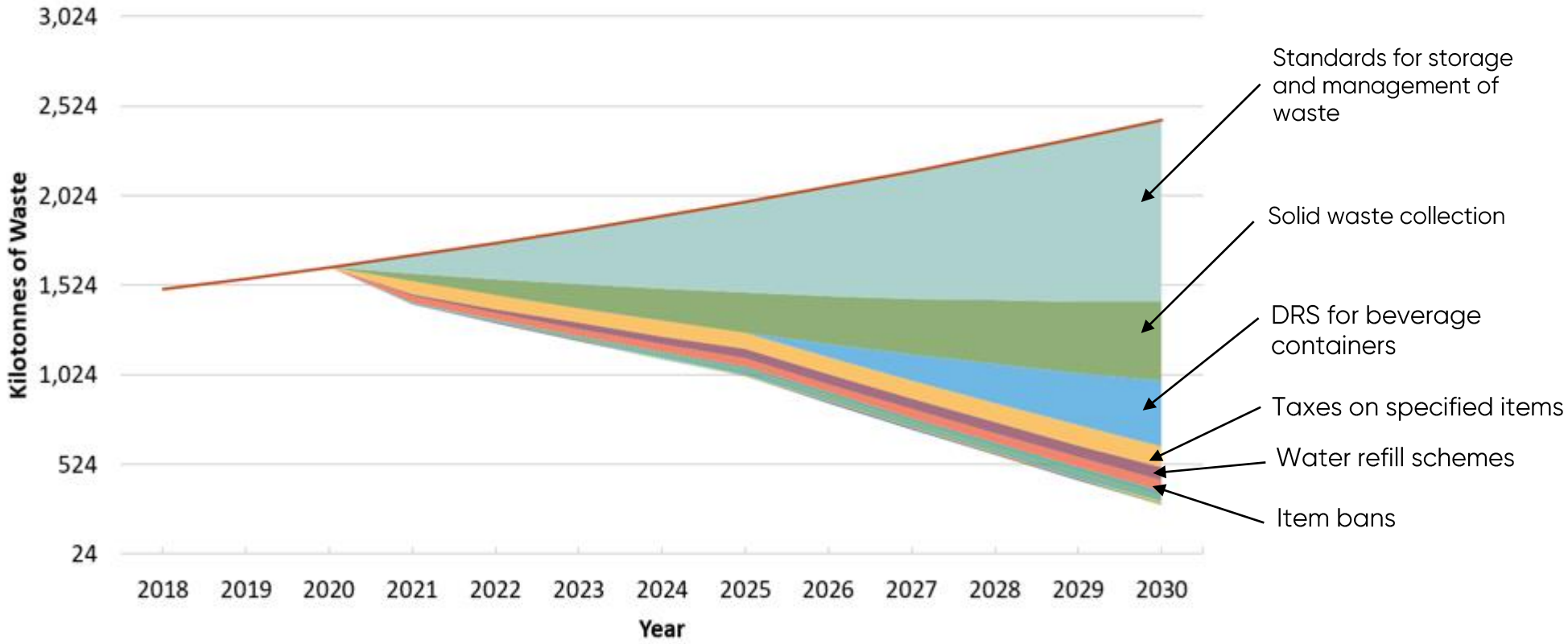
The key interventions that make up most of the reduction are:

- Standards for storage and management of waste
- Solid waste collection
- Deposit Refund Systems (DRS) for beverage containers
- Taxes on specified items
- Water refill schemes
- Item bans

In this example, the item-specific bans (straws, stirrers, expanded foam take out containers, cups and plates, and cutlery) and taxes (plastic bags, hard plastic take out containers, cups and plates, balloons and wet wipes) are assumed to be implemented in the short-term, so the effect is to achieve maximum reduction of leakage of plastics into the marine environment associated with these instruments in early years, with the same reduction being maintained out to 2030. For other interventions, such as standards for storage and management of wastes, it is assumed it would take some time

for the roll-out to be implemented at a country-wide scale. Hence, the profile of this particular wedge starts off with lower leakage reduction in the short-term, with the maximum contribution to preventing the flow of plastics into rivers and seas achieved towards the end of the period. A DRS for beverage containers is unlikely to be implemented straight away as the focus should be on improving basic waste services in the short term, so the intervention is only applied from 2025. Whilst improvements in solid waste collection are a clearly understood solution, the wedges approach shows how much impact basic systems can have on stemming the flows of plastics into the sea, relative to other policies. The cross-cutting nature of basic collection services suggests the clear direction for immediate and necessary action in the country should be in implementing these fundamental systems.

Figure 5-2 Example wedges output for Indonesia



In summary, this example from Indonesia shows a quite different picture from that of the UK, with a much greater effect on the flow of plastics into oceans coming from the measures affecting 'macroplastics', such as those items found in household waste. This is because these are often disposed of in the open, sometimes directly into rivers and seas, so they are major contributors to the flow of plastic waste into the oceans. Although – as in the UK – microplastics make a contribution, in the business as usual scenario, it is the macro-plastic flows that contribute most to the problem of plastic flowing into rivers and seas. It is clear that basic improvements in the collection, storage, treatment and disposal of waste can have a significant impact on total leakage of plastics into the marine environment in countries where waste collection services are not so well developed.

Therefore, a key focus should be on improving the country's waste management system. This requires funding, and the key tool to cover the costs of collection, recycling or disposal of waste, much of which is packaging plastics, is extended producer responsibility. For other items with clear alternatives, such as single-use carrier bags, charges should be used, or outright bans, partly with a view to making early gains.

It should be noted that to the extent that there is deemed to be some leakage of plastics into the marine environment associated with exports of plastic waste from the UK and other countries to less well managed facilities, then improved waste infrastructure in Indonesia might be expected to reduce the s of this problem to the extent that these exports continue. Reports indicate that, according to Indonesia Statistics, there was an increase in imports of 141% (283,152 tons) of plastic waste and scrap in 2018, whilst exports fell by 48% (98,450 tons) on 2018 alone.[17] Exports and imports are operating from business-to-business; however, sometimes there are irresponsible practices in reality: companies are selling or providing their imported plastic waste and scrap to collectors outside of their factories. This assumes that Indonesia does not restrict imports of plastic waste, action which it has not taken thus far even though neighbouring countries, such as Thailand and Vietnam, have taken such measures. Indeed, as noted above, Article 11 a (8) of the Waste Framework Directive already requires waste that is exported from the EU to be recycled at facilities under conditions equivalent to those in the EU.

[17] See https://www.balifokus.asia/single-post/2019/03/22/Export-and-Import-of-Plastic-Waste-Situation-in-Indonesia-Implications-of-National-Sword-China-Policy (note that the article indicates that this has increased the mount to be managed, domestically, by 184,702 tonnes: this is the difference between the increase in imports and the reduction in exports. However, if the figures are correct, our understanding is that the increased burden on management within country is the sum of the increase in imports and reduction in exports, which would equate to 381,602 tonnes of plastic. Clearly, if a significant proportion of this material is mismanaged, then the net effect just of the increase in material managed in Indonesia in 2018 would potentially be greater than the total amount finding its way into rivers and seas from UK sources based in the UK.

Annex

A.1.0 Description of the Model

The model includes mass flow data on key items of plastic waste (both macroplastics and microplastics). The list of items was derived using the International Coastal Cleanup dataset and other research on the prevalence of micro-plastic leakage into the marine environment, and is presented below in Table 2-1. The model also used projections of future consumption (and therefore waste generation) of each item in the absence of any intervention (i.e. the baseline scenario).

The various pathways through which plastics flow into rivers and seas were identified (see Figure 2-3) and estimates of the proportions of waste flowing through each pathway (known as transmission factors) were developed. This work drew from a significant body of research, which incorporated data from a wide range of sources, e.g. the effect of current policies, waste management strategies and behaviours pertaining to plastic use and littering. In the absence of primary data, best estimates were based on reasoned analysis, data gathering for each country and contributions from a group of specialist experts.

The model goes on to estimate the anticipated impact of specific interventions on these baseline flows of plastics in order to identify those that are likely to be the most effective in addressing leakage of plastics into the marine environment in a particular country's context. Figure 2-4 below summarises the design of the model and the information that was used in developing it.

Table 2-1: Plastic items included in the model

Macro plastics (97% of beach litter counts):

- Grocery bags (Plastic)
- Other Plastic Bags
- Beverage Bottles (Plastic)
- Bottle Caps (Plastic)
- Lids (Plastic)
- Other Plastic Bottles (oil, bleach, etc.)
- Cigarette Butts
- Straws, Stirrers
- Food Wrappers (candy, chips, etc.)
- Single serve sachets (food)
- Single serve sachets (non-food)
- Take Out/Away Containers (Foam)
- Take Out/Away Containers (Plastic)
- Cups, Plates (Foam)
- Cups, Plates (Plastic)
- Forks, Knives, Spoons
- Balloons
- Wet wipes
- Diapers
- Condoms
- Sanitary pads/ tampons
- Fishing Gear
- Construction plastics
- Other plastic items (data deficient)

Micro plastics (prior studies):

- Tyre Wear
- Brake Wear
- Clothing Fibres
- Pellets
- Microbeads

Figure 2-3: Plastic pathways diagram

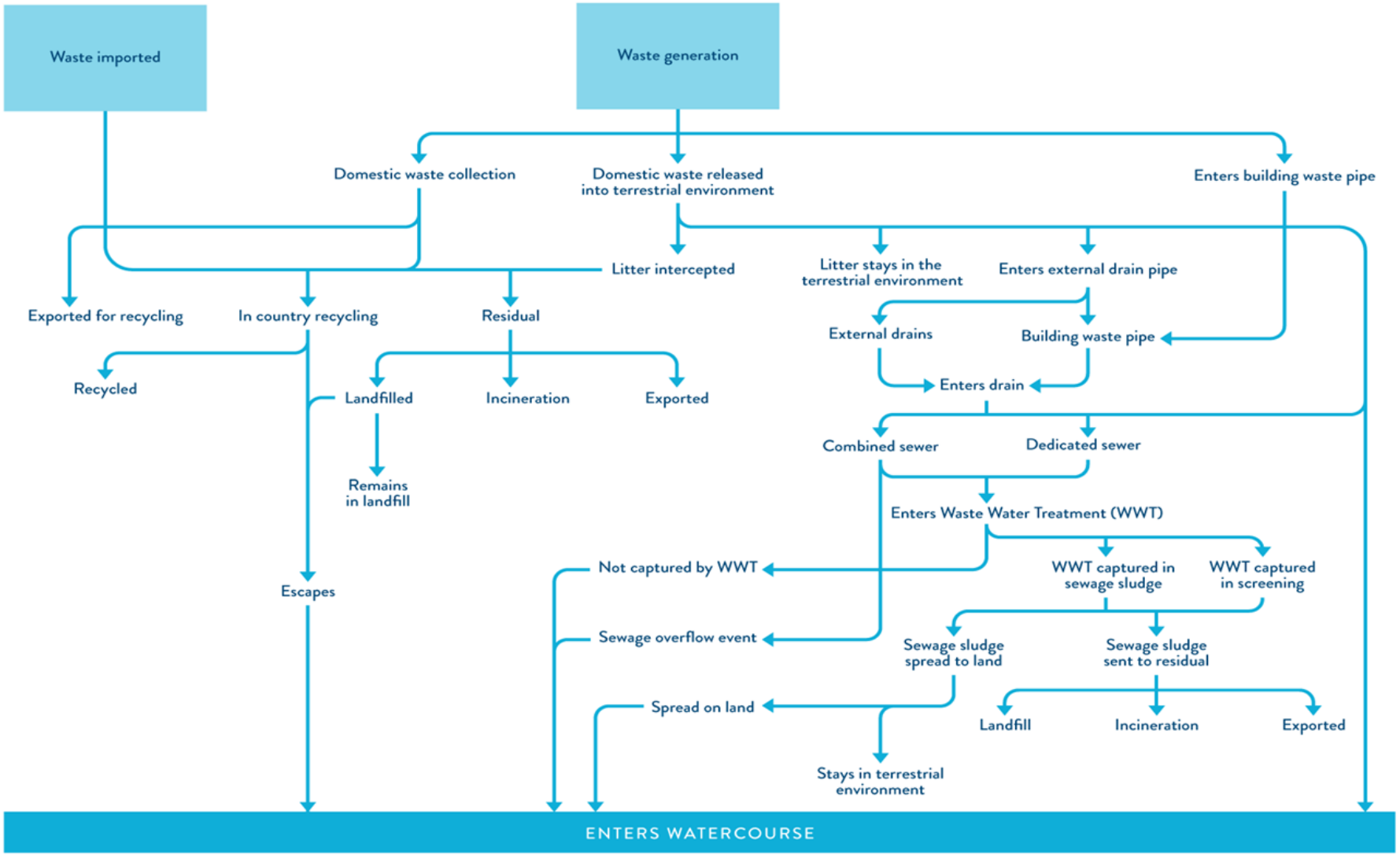
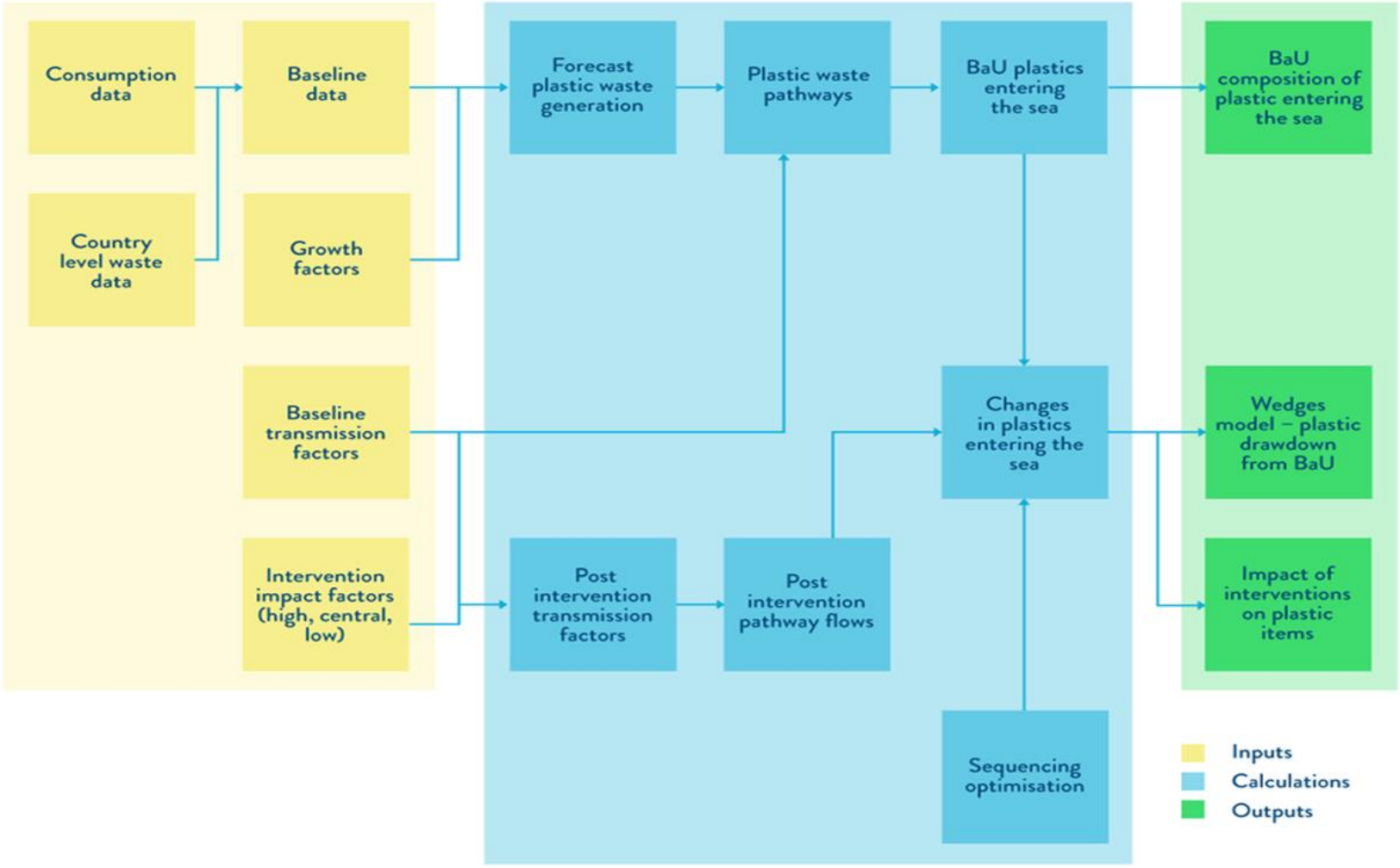


Figure 2-4: Model flow diagram

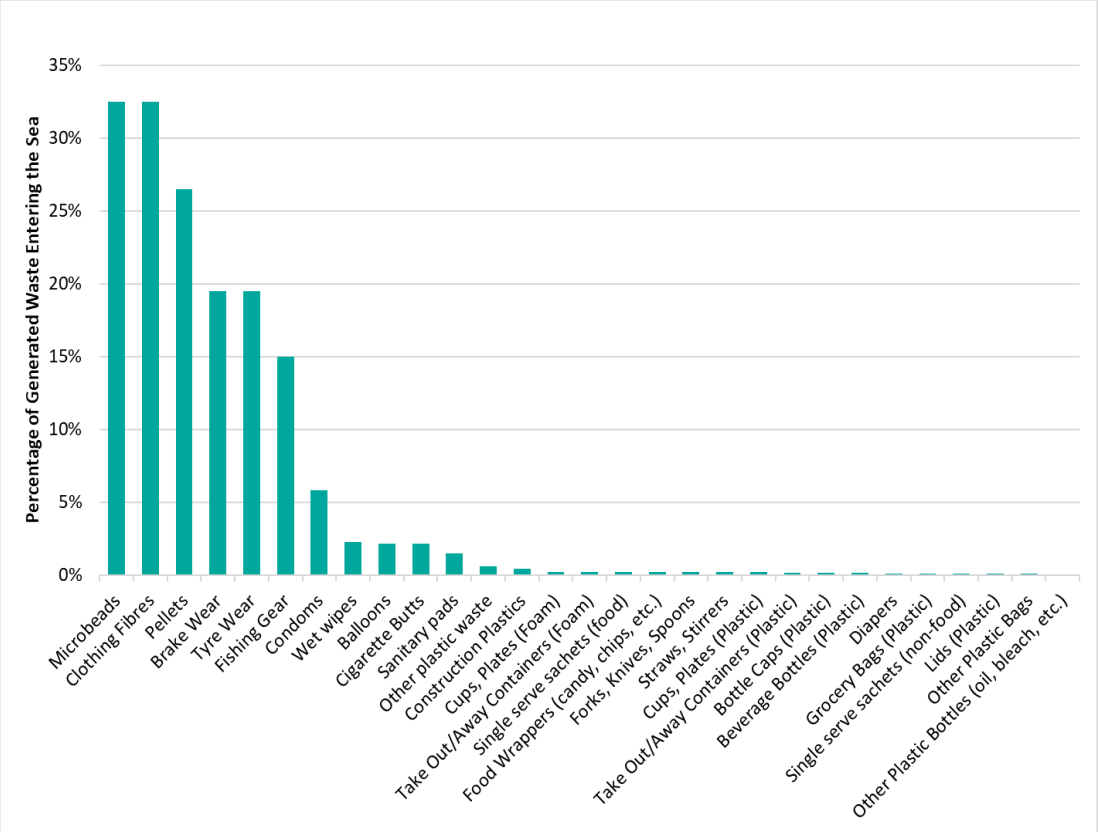


A.2.0 Model Flows

Data on waste generation are unavailable, or are not freely accessible for many of the items, because waste data in the UK is not at the same level of granularity as the classification of items identified in beach litter counts. However, data on the amounts of various items placed on the market was more readily available. The use of consumption data as a proxy for waste generation data was considered appropriate, given the single-use nature and short lifespan of most of the items on the list.

As indicated above, for each item type the flow of plastic from the point of waste generation to final destination was mapped using the pathways set out in Figure 2-3. The total effect of the transmission factors throughout the whole pathway for each item is shown in Figure 2-5. As many microplastics enter watercourses directly, and wastewater treatment works do not screen out a lot of micro-sized materials, the overall transmission of microplastics is very high compared to macro items.

Figure 2-5: Percentage of generated waste entering the sea



The total flow of plastic entering the sea from different pathways was calculated and is summarised in Figure 2-6. The most significant flow is estimated to occur from tyre dust. However, this estimate has a high degree of uncertainty associated with it. The transmission factors estimated for the UK are based on the pathways calculated for microplastic emissions in one of

Eunomia's previous studies for the European Commission.[18] An average of the ranges modelled for that study were taken. The evidence regarding the potential transmission of tyre dust from roads to the sea is currently being built upon by a key study from Defra. Given that the certainty in the amounts generated is quite high, and it is plausible that particles of tyre dust could be part of the suspended solids in watercourses which drain out into the sea, it seems prudent to include this flow with the precautionary principle in mind. The next largest flows are again microplastics, pre-conversion pellets used in the manufacture of plastic items and synthetic fibres from the washing of clothing. Wet wipes are fourth in significance, which is consistent with their high prevalence in beach litter counts and in key rivers through large urban areas, such as the Thames, where tens of millions of litres of raw sewage are discharged each year due to combined sewers overflowing in storm events.[19]

Beverage bottles are the most significant macro plastic contributor to marine plastics. This is due to the significant amount of bottle waste generated each year, and the fact that they are often consumed on-the-go and become litter, which can blow or be washed into drains, rivers and ultimately the sea.

Fishing gear also features quite highly on the list. Despite the relatively low tonnages of fishing gear waste produced, what is lost ends up directly in the sea. The next most significant are again microplastics - brake wear and microbeads. The fact that many microplastics are significant contributors to the total leakage of plastics into the marine environment relates strongly to the high proportion of these items that become waste that enter the sea.

Construction plastics, other plastic bottles and take-out containers are the next most significant items, due to the higher quantities generated and the potential for mis-management. The remaining items are smaller light-weight products or pieces of packaging mainly associated with on-the-go food service.

As the consumption of these items is forecast to increase over time, the total leakage of plastics into the marine environment is also predicted to rise.

[18] Eunomia Research & Consulting (2018) *Investigating options for reducing releases in the aquatic environment of microplastics emitted by (but not intentionally added in) products*, Report for European Commission, February 2018

[19] BBC (2019) *Thames Water bills rise to pay for Thames super sewer*, https://www.bbc.co.uk/news/uk-england-19898168

Figure 2-6: Baseline waste entering the sea, kt per annum

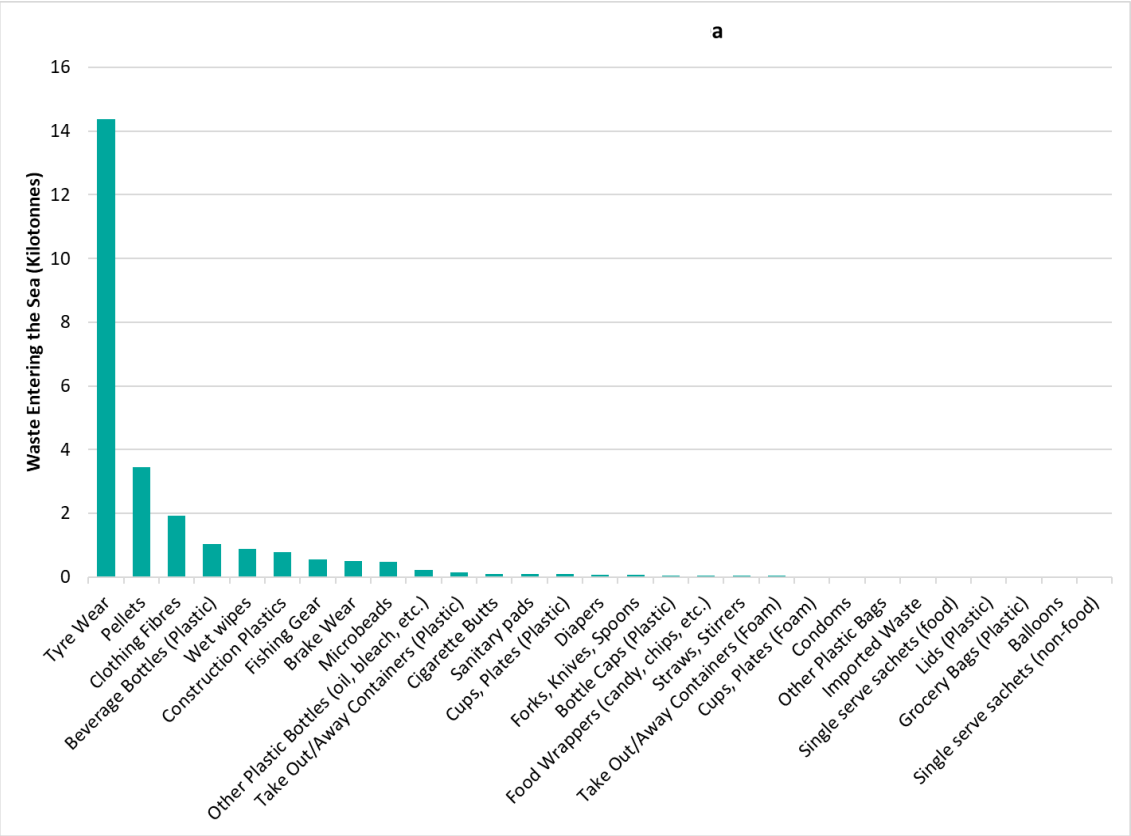


Figure 2-7 highlights the key points of entry to the aquatic environment for leakage of plastics into the marine environment. The most significant points of entry are discharge of water from wastewater treatment (WWT) plants which contain suspended microplastics. Where microplastics, or other items, enter surface water drains they get discharged to watercourses which flow into the sea, hence entering the sea via drains is the next most significant source. Another significant point of entry is where litter gets blown into watercourses and carried to the sea. Discharge of items, such as wet wipes, during sewer overflow events is a less significant source, and smaller sources still include items blowing off landfills before cover is put in place and microplastics in sewage sludge that is spread to land washing off into streams and rivers.

Figure 2-7: Points of entry to marine environment