Highway Drainage:

The Route to Surface Water Management

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The Importance of Surface Water Management for Highways

Managing surface water has always stood as a crucial element in the safe operation of transport infrastructure. Without the appropriate solutions, standing water on roads poses a multitude of problems; poor driving conditions, pedestrian safety issues, surface deterioration and flood risk are all prevalent impacts that can harm both the urban and natural environment, as well as those who interact with it.

The need for surface water management is even more pertinent when the growing erraticism of our climate is acknowledged. More specifically, extreme precipitation has become a growing occurrence as climate change continues to cause adverse weather conditions.

Five of the 10 wettest years on record in the UK have happened since 2000, with latest reports suggesting that extreme rainfall events could become twice as likely in London by 2040. The flooding of the capital in July 2021 serves to further illustrate the exacerbation of severe conditions.[1]

With these developments in mind, it is clear that drainage systems are now more important than ever for urban infrastructure. At the same time, industry standards and environmental impacts will need to be addressed throughout such projects. It is the responsibility of highways engineers to carefully consider the solutions available and ensure these are designed to perform both effectively and sustainably.

ACO Water Management wanted to delve deeper into the matter at hand and determine whether highway schemes are in fact putting the right solutions in place. Working with Censuswide, the business surveyed 100 infrastructure and highways engineers in May 2022 to shed light on the key priorities and challenges when it comes to implementing drainage for roadways. Through this research, ACO aims to identify solutions and best practices that can enable industry professionals to successfully manage surface water across highways.

1 https://www.metoffice.gov.uk/about-us/press-office/news/weather-and-climate/2021/future-extreme-rainfall-more-extreme-than-first-thought

Key findings

30%

Linear drainage channel capacity is deemed least important in drainage design.

55%

Have worked on projects without maintenance of drainage taken into account.

Only 1%

Do not face any barriers in SuDS schemes.

Only 56%

Fully understand load class specification requirements for linear drainage channels.

Only 44%

Fully understand the Simple Index Approach to the SuDS Manual.

53%

Agree that wildlife mitigation is an afterthought in projects.

Product design

Design and specification are key to developing drainage systems that will meet the individual requirements of any project. Here, relevant standards must be kept front of mind as means of guidance. The Manual of Contract Documents for Highway Works (MCHW) and Design Manual for Roads and Bridges (DMRB) stand as reference points for determining surface and subsurface types of drainage, as well as providing further detail into specific systems. At the same time, design standards may vary depending on the location and road type. It is therefore paramount that local authorities are consulted when approaching a highway scheme.

While these guidelines are in place to help navigate the design process, it seems there is still a level of misunderstanding among infrastructure professionals. When survey respondents were asked what aspect of drainage channel design they deem most important, there was no overwhelming feature that emerged in the results. This could indicate a lack of clarity around the key considerations when designing drainage schemes.

Load class

Building on this, just over half (56%) agreed that they fully understand the specification requirements for highways works in relation to linear drainage channel and combined kerb drainage load classification. Interestingly, only 28% 'strongly agreed', with the other 28% only 'somewhat agreeing'. Despite the MCHW providing guidance within this remit, there is an element of interpretation involved. Supported by the statistics, it is clear that uncertainty does pervade when specifying load classes in highway drainage design.

The consideration of the appropriate load class must be based on traffic and application if the risk of failure is to be minimised. For highways, drainage channels will need a minimum of Load Class D 400 to withstand the burden of moving vehicles. In exceptional circumstances where the application is more likely to be subject to high impact from heavy goods vehicles (HGVs), class E 600 may be selected. Lighter class C 250 units can only be installed in locations that are protected from direct traffic loading, such as areas behind safety barriers.

Load Class	EN 1433	Typical uses
A 15	**A 15**	Pedestrian, cycleways, minimally trafficked areas (light domestic vehicles only).
B 125	**B 125**	Pedestrian precincts, light vehicles, private car parks and drives.
C 250	**C 250**	Parking areas, service stations (cars) and slow-moving light commercial vehicles.
D 400	**D 400**	Public Highways, parking areas for all types of vehicles.
E 600	**E 600**	Industrial areas, heavy wheel loads, slow-moving HGV's and forklifts, service stations.
F 900	**F 900**	Airport runways, very heavy industrial and military installations, service yards and lorry parks.

Figure 1

Channel capacity

Among the options provided in the survey, the aspect deemed least important was channel capacity (30%) – perhaps surprising given its significance in managing water on the highways network. Industry standard software such as MicroDrainage or Causeway Flow can be used in tandem with Channel Design software, such as ACO's online Quad tool, to incorporate and fully exploit the capacity provided from linear drainage channels within a whole site drainage model.

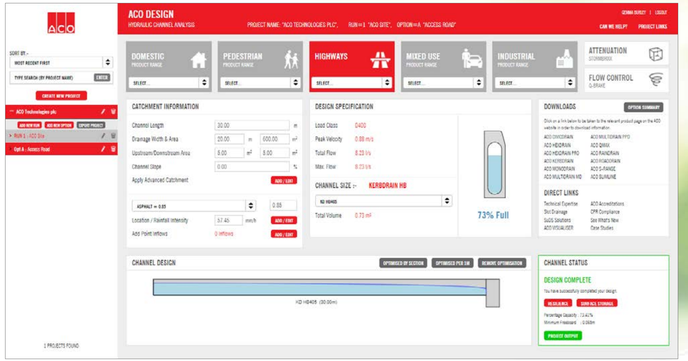
It can be assumed that full channel integration embedded within a drainage network model is often overlooked due to being a time-consuming process to factor into design, despite being a cost-effective approach in the long term. Without considering appropriate capacity, drainage systems can overflow and inevitably lead to site flooding. Infrastructural damage can subsequently prove to be a more exorbitant process due to the repairs and potential retrofitting required. Going forward, highways engineers need to make the most of design consultation during these decisions.

Software tools

Software tools are intrinsic to accurate design and specification of drainage systems. When asked about the application of such platforms, industry response was more encouraging. Almost 70% use either MicroDrainage, Causeway Flow or ACO QuAD when designing drainage channels.

As more than 30% of respondents confirmed they do not use one of the three tools specified, there is an opportunity for those working on highways projects to apply software, like ACO QuAD, more often. ACO's QuAD software provides a platform for engineers to factor in specific design of the channel. QuAD Hydraulic Design 2.0 enables the user to select location and design parameters of the solution to establish the recommended capacity in line with rainfall intensity forecasts.

It must be said that it is best to use these tools collectively to achieve optimum performance in drainage systems. QuAD can be applied to determine the sizing of the channel before running further software platforms such as MicroDrainage and Causeway Flow to accurately model the overall network design. Highway engineers should also consider undertaking relevant training sessions and CPDs from software providers to ensure platforms are being used to their full potential during design and specification.



Product application

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Combined kerb and drainage

Combined kerb and drainage systems consist of a one-piece design to satisfy both surface water management and infrastructure protection within a singular component. It also eradicates problems associated with incorrectly sited point gullies by ensuring all surface water runoff is safely removed over the entire length of the installation.

ACO's KerbDrain range is available in half-battered (HB) or splayed (SP) profiles, and has a variety of unit depths available for optimum hydraulics in any highway scheme. Fully certified to BS EN 1433:2002 Load Class D 400 or E 600 ranges, its Vienite® manufacture has high compressive strength and is therefore extremely impact resistant.

Installation is integral to the performance of a Load Class. As long as the system is correctly installed, it will be able to withstand high-impact collisions.

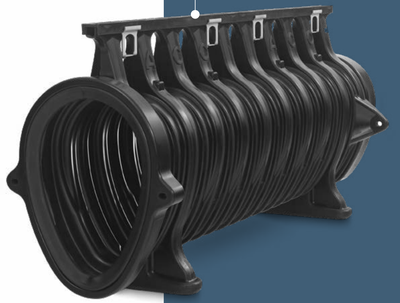
It is for this reason that a durable concrete bed and surround is essential. A common error observed during installation is implementing combined kerb and drainage to the same specification as a standard concrete kerb. As a combined kerb and drainage unit is hollow, it must be encased in stronger and more extensive concrete around the component for the same level of robustness.

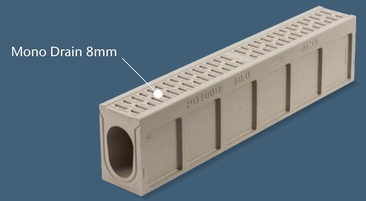
When situated on a roundabout, or such areas where the unit is more likely to be struck from the side by HGVs, it is recommended that the concrete profile extends all the way to the top of the kerb at the back for added support.

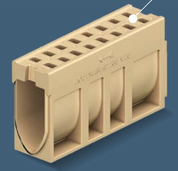
Monolithic channel systems

For channel systems, National Highways and local authorities predominantly require monolithic systems. As the gratings and covers are integrated with the channel, this reduces the risk of separate gratings becoming dislodged. ACO's RoadDrain consists of a one-piece design to provide a highly effective alternative to traditional two-part channel and grate systems.

It should be noted that grating widths are a key consideration for channels. BS EN 1433:2002 is the applicable standard here, and outlines the permissible widths of gratings in their relevant locations. Pedestrian zones such as crossings will require narrower channel slot widths of typically 8-10mm, while wider slots widths up to a maximum of 42mm should be specified for motorways to reduce maintenance and risk of slot blockage.







Sustainable Drainage Systems (SuDS)

Controlling the quantity and quality of runoff is critical to managing flood risk and preventing pollution. As water is discharged into swales and ditches in SuDS schemes, there is a risk of pollution if the water is not appropriately treated beforehand. It must be kept in mind that natural resources can only clean water to a certain point. SuDS schemes will therefore need to incorporate proprietary products as well to appropriately treat surface runoff.

By adhering to SuDS principles, transport infrastructure can facilitate and sustain better environments for both people and nature. The SuDS Manual (CIRIA C753) offers comprehensive guidance for planning, design, construction, operation and maintenance of water management systems.

In addition, the Simple Index Approach (SIA) helps determine whether the proposed SuDS are adequate mitigation for the pollution hazard of the development. One concern, however, is that only 44% of ACO's survey respondents agreed that they fully understand the SIA to the SuDS Manual and how to design to it. Of those who agreed, only 10% were fully confident – clearly indicating a lack of knowledge in this area.

Moreover, providing SuDS for new roads and redevelopments can present highways engineers with significant challenges in managing the quality and quantity of the surface water runoff. When asked about the main barriers they faced, only 1% of respondents said they did not face any. At 40%, lack of knowledge was again a major factor – this time in understanding what proprietary products were available.

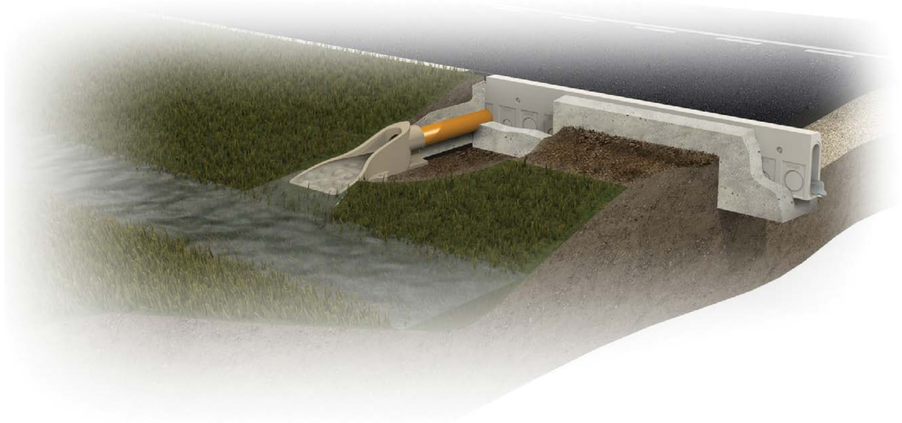
With these statistics in mind, infrastructure engineers evidently require better guidance around the applicable proprietary solutions and how these can be integrated to overcome the major industry challenges in SuDS for highways.

Space

One of the principal barriers quoted by survey respondents was the space to incorporate SuDS on site (46%). Proprietary solutions are beneficial where there are space constraints on site, as they are often the most viable options if the surface water management system is largely underground.

SuDS Manual, Section 14.1:

"They (proprietary treatment systems) are especially useful where site constraints preclude the use of other methods or where they offer specific benefits in facilitating the delivery of SuDS design criteria for a site. They are often (but not always) subsurface structures and can often be complementary to landscaped features."

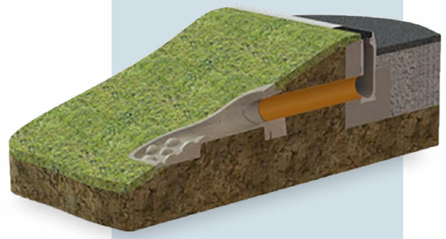


When retrofitting drainage systems, existing infrastructure such as sewer and water pipes or fibre-optic cables, can pose obstacles to application due to the lack of depth available. It is in these scenarios with limited space that ACO's KerbDrain can prove to be a valuable solution. Due to their shallow profile and high invert specifications, such systems aid installation where underground services are near the surface.

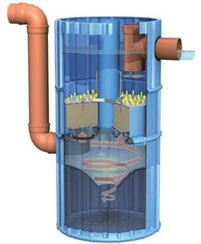
Integration

Engineered and natural solutions will often need to be applied in tandem for scenarios where "soft SuDS" cannot manage surface water alone. Here, KerbDrain can be successfully implemented by allowing engineers to combine the benefits of hard SuDS with traditional soft SuDS solutions such as swales, ponds and wetlands. The comparatively shallow inverts of these units offers a high degree of functionality when connecting to green infrastructure in this instance, enabling direct integration with swales, for example.

As channels, such as KerbDrain, collect runoff, the next step is to consider applications for treating water quality in line with the SIA. When asked what solutions they are installing to help clean water in their projects, almost half of respondents said they aren't installing filtration units or using separators. Given this proportion, highways engineers need to be made more aware of integrating proprietary solutions to sufficiently mitigate pollutants.



ACO's V-Septor is a hydrodynamic separator that removes sediment bound contaminants. Its design enables the removal of pollutants by means of settlement and the capture of floatable objects. The system forms an integral part of SuDS management thanks to its ability to remove over 50% of fine total suspended solids, as well as sediment bound metals and hydrocarbons.



Also part of ACO's clean range, the QuadraCeptor can be implemented as a filtration system that provides higher-level water treatment. The solution is designed to remove heavy particles, silt, nutrients and dissolved materials in a four-stage process to ensure insignificant levels of pollutants are present in the runoff before infiltration or discharge.

Site attenuation (hold) is another area where engineered solutions may be applied. Geocellular crates can often be integrated into verges adjacent to the highway to aid with attenuation and/or (if ground conditions permit) infiltration as a soakaway. ACO's StormBrixx range provides a geocellular tank that can be installed beneath a verge for these types of applications to safely drain excess rainfall and prevent flooding.

Cost

With budget constraints a common issue for local authorities, it is understandable that cost was revealed to be the most prevalent barrier for highways engineers (48%). Nevertheless, identifying cost-effective drainage solutions can help to value-engineer SuDS in highways projects.

Standard KerbDrain ranges are now available in one metre length channels, reducing the associated installation costs across highway projects. For footway areas away from the carriageway, ACO's MonoDrain channels' high-strength profile means less haunching is required for installation. Due to reduced concrete bedding costs, significant savings on materials can be accumulated over the course of development.

The ACO Qmax high-capacity slot system is another option for cost-effective surface water drainage and attenuation. Available in six sizes and specifiable to all load classes, the range ensures greater flexibility in application for engineers. This can help to minimise the number of drainage outlets required and greatly simplifies connecting to existing infrastructure for both new and retrofit SuDS schemes. Channel sizes may also be combined to form step fall systems, reducing costs and optimising hydraulic designs.

Maintenance

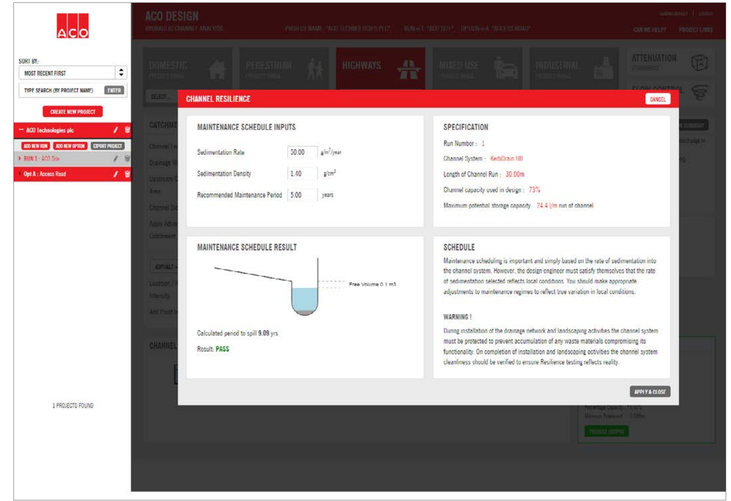
Maintenance is vital to all facets of a highways scheme's success. Without appropriate care, drainage performance deteriorates through sediment and silt build-up. This leads to overflows and flooding, causing costly damages to infrastructure and the wider environment. Despite the risks, such practice is a regular afterthought in projects, and tends to be the first measure cut in line with budget constraints.

Indeed, ACO's survey results revealed that this is often the case. While two-thirds (67%) of respondents were confident of a clear maintenance strategy being put in place post-installation, only 22% were very confident. Cause for further concern is the fact that 55% of respondents have worked on a project where maintenance has not been factored into the design of the drainage system. It is with these figures in mind that project managers not only need to more closely consider maintenance scheduling, but also factor such operations into the development stage.

As such, highways engineers need to prioritise accessibility when deciding solutions. Water-jetting combined kerb and drainage units and channels should be common practice, and therefore access points are required. When cleaning, pressure should be controlled to prevent water and debris spraying back out of channel slots onto the highway surface. Inspection and cleaning can be effectively carried out for geocellular systems using the same type of equipment, and can also be aided with CCTV to visually navigate through the structure if required. As with any type of drainage system, close visual inspection on a regular basis is vital.

In terms of scheduling, different channels will require different timelines for maintenance – also depending on location. Factors such as leaf fall from nearby trees and heavy traffic will significantly contribute to the build-up of debris. DMRB CD 523 is a useful point of reference here as it gives valuable guidance on assessment of sediment deposition. ACO have also previously undertaken research in this area along with Middlesex and Cranfield Universities to shed further light on the accumulation processes from road surfaces.

ACO's online design tool, QuAD Hydraulic Design 2.0, may be used in conjunction with documented guidance to help forecast sedimentation build-up in relation to channel capacity, and provide a guideline of how often maintenance should be carried out. Users can simply input parameters around sedimentation rate and density for a maintenance period guideline. This can be easily and quickly integrated when already using the software to determine other design elements such as channel capacity.



Wildlife support

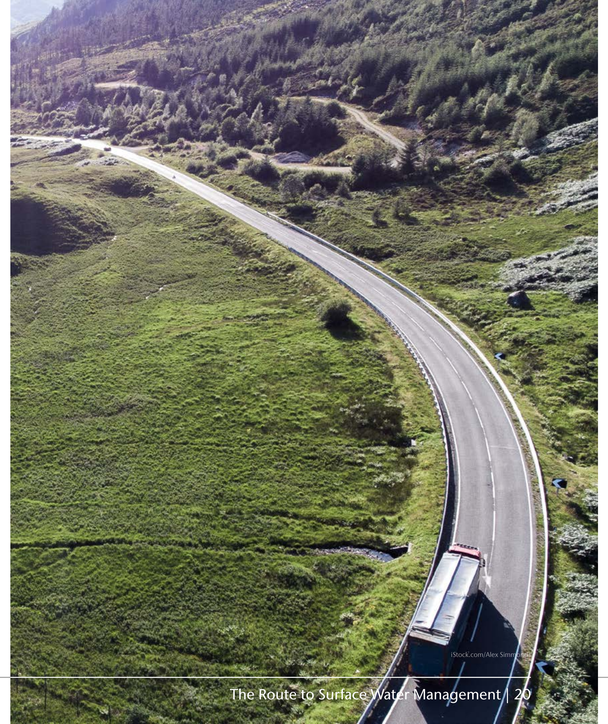
Building on SuDS principles, protecting biodiversity is another vital element that cannot be overlooked. Habitat guidance in CIRIA's SuDS Manual, under chapter 6 (Designing for Biodiversity – 6.2.3), states that within any new SuDS scheme, it should link with other local and/or regional habitats to help build and enhance habitat connectivity. Furthermore, the Environment Act 2021 formally mandates within the planning system in England that projects must achieve a minimum 10% biodiversity net gain.

Roads, by their very nature, are responsible for considerable loss and fragmentation of habitats, giving rise to significant impacts on biodiversity and species population.

Worryingly, more than half of survey respondents (53%) agree that when designing highways projects, wildlife mitigation is an afterthought and is led by ecologists.

Only 26% disagree that wildlife mitigation is an afterthought. Clearly, biodiversity needs to be prioritised more across highways schemes, not just to realise SuDS and the importance of preserving and enhancing natural habitats, but also to avoid potential litigation.

Migration routes, population and species all need to be considered when approaching highways projects – particularly when identifying drainage applications. Input from ecological experts is of critical importance here to understand what species would be affected and the applicable solutions. This will need to be factored into the early stages of a project as an integral part of the design before it is too far down the line to be effectively incorporated.



There are several ways infrastructure engineers can integrate wildlife mitigation measures into highways schemes:

Wildlife kerb

AAmphibians typically follow the side of the kerb along the road, as they are naturally inclined to proceed along any vertical barriers. This can direct them straight into a traditional roadside gully pot, causing them to become trapped. One option is to relocate the gully away from the kerb. However, this can be costly with potential impacts on the performance of the drainage, which is why a wildlife kerb with a recess is a viable alternative to help protect amphibians.

Wildlife escape ladder

During migration periods, amphibians and small creatures often fall into road gullies. Although easy to enter, these species will be unable to climb out. Escape ladders should therefore be installed within a gully to allow any trapped animals to safely exit. Constructed from a mesh material, ACO's wildlife gully ladder provides a stable footing for animals that is easy to grip and climb, with stainless steel weighting bars preventing the ladder from rising during heavy rainfall.

Guide tunnel

It is important to prevent fragmentation and create a safe link between habitats and water-borne areas by using guide walls and crossing tunnels. These direct and allow animals to cross the road at safe locations. ACO's climate tunnel enables secure passage for species under roads and reduces the crossing distance. Tunnels are available in either slotted or solid-top variants, depending on conditions. A slotted design is installed at the surface, whereby its elevation benefits from reduced risk of flooding.

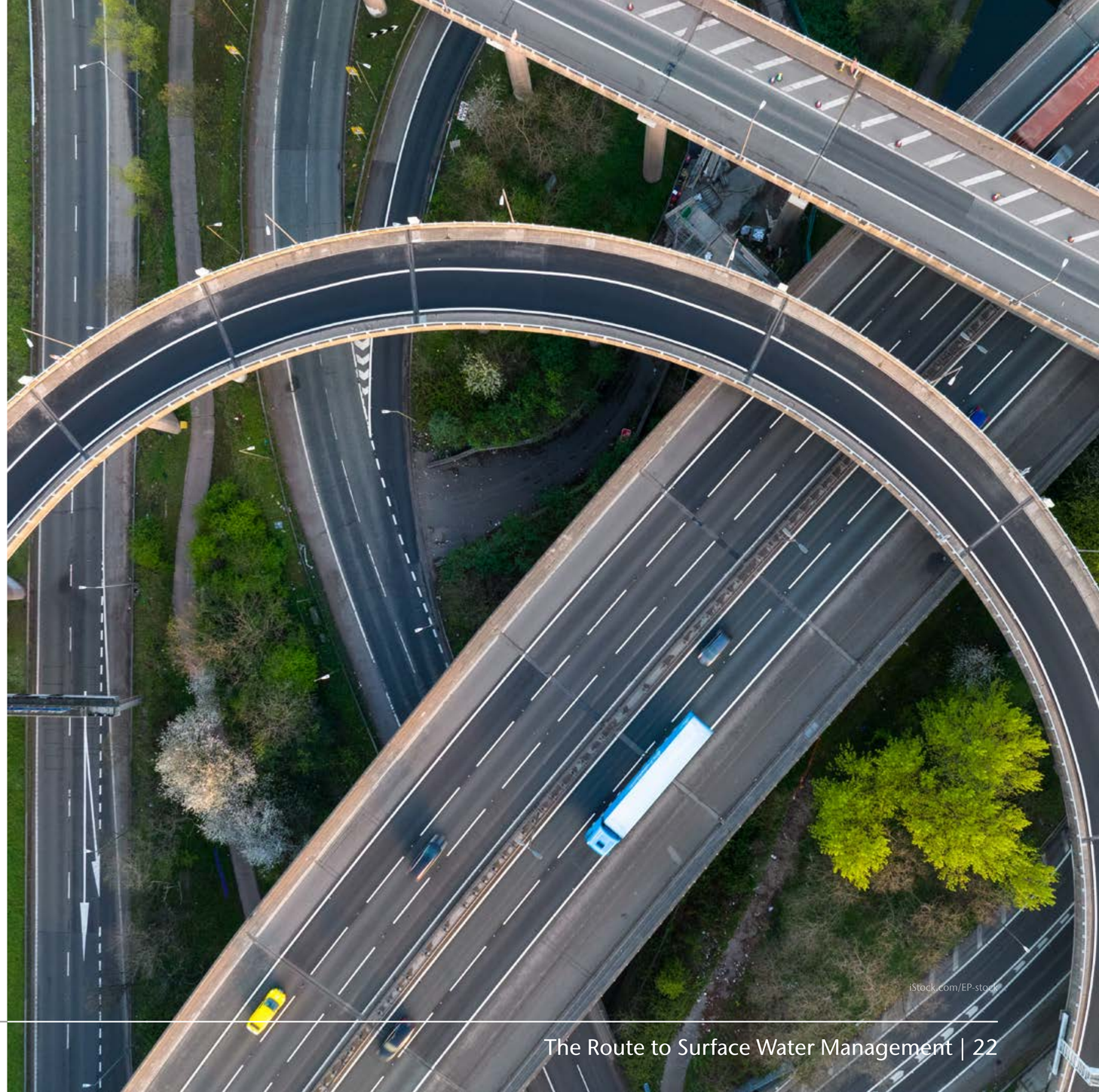
Conclusion

ACO's survey results show that although highways engineers are taking steps to manage surface water effectively, there remain areas that require further attention. With sustainability, performance and maintenance collectively held up as key priorities, the industry needs to work collaboratively to meet these demands.

Simultaneously, the challenges in achieving these ambitions need to be addressed. Through guidance and knowledge, highways can be equipped with effective drainage systems that also protect and enhance biodiversity and continue to perform for decades to come.

Understanding the different products available and how to design these effectively is the first – yet most important – step a highways engineer can take. By consulting drainage manufacturers like ACO, along with local authorities and ecologists, surface water management can be tackled from all angles.

For more information, get in touch with the ACO team today at **technical@aco.co.uk.** They can help design the right solution to meet your project's requirements.



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