BALTFLOODS, Baltic Flood Resilience and Digital Solutions

Deliverable 1.1
Framework for Piloting and Evaluating

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Interreg
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BALTFLOODS

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About BALTFLOODS Project

BALTFLOODS aims to enhance flood preparedness and mitigate runoff pollution in cities across the Baltic Sea region by leveraging digital and technological solutions and engaging citizens as key stakeholders. The project addresses three main challenges aligned with the thematic scope of Priority 1 of the Interreg Baltic Sea Region Programme, particularly Objective 1.2. Firstly, BALTFLOODS will improve disaster preparedness and response to floods by implementing advanced monitoring systems that provide real-time data for timely interventions, benefiting local and national public authorities, infrastructure owners, and service providers. Secondly, the project will decrease the discharge of polluted stormwater, thus enhancing environmental quality and public health. This involves monitoring water quality through innovative approaches that support environmental and public health goals. Thirdly, BALTFLOODS will increase community engagement in flood and water pollution issues through participatory tools, empowering citizens and educational institutions to take an active role in environmental stewardship. By fostering a well-informed and proactive community, the project builds societal resilience to environmental threats. Transnational cooperation will be essential to facilitate knowledge exchange, policy alignment, and resource pooling to enhance the scalability and sustainability of the solutions, ultimately benefiting urban populations and the Baltic Sea Region ecosystem.

Learn more about the project:
www.interreg-baltic.eu/project/baltfloods

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Executive Summary

BALTFLOODS is a collaborative project aimed at enhancing flood preparedness and reducing polluted stormwater runoff across Baltic Sea region cities. The project leverages advanced digital tools and involves citizens as key stakeholders to address three main challenges: **(1)** improving disaster preparedness and flood response through real-time monitoring, **(2)** decreasing discharge of polluted stormwater to protect water quality and public health, and **(3)** increasing community engagement in flood and water pollution management. By integrating cutting-edge technologies (like remote sensing, sensors, and data analytics) with strong stakeholder involvement, BALTFLOODS aims to build more resilient and environmentally healthy cities. Transnational cooperation and knowledge-sharing are core to the project, ensuring solutions are scalable and benefit the broader Baltic Sea region.

This document outlines the framework for implementing BALTFLOODS' digital tools and engagement strategies. It is written for a wide audience – including public authorities, citizens, and technical partners – and balances accessibility with technical depth. The following sections present the planned digital tools, the approaches for stakeholder engagement and citizen participation, the data integration and governance strategies (with an emphasis on the FIWARE platform), and the evaluation plan (indicators, monitoring tools, and risk assessment). Throughout, practical considerations such as tool limitations, data standards, and feedback integration are highlighted. This comprehensive plan will serve as a foundation for the pilot implementations in Lappeenranta (Finland) and Gjøvik (Norway), setting the stage for effective deployment in these pilot cities and future replication across the region.

This framework is grounded in a **systematic mapping of technical and stakeholder needs** carried out in WP 1. The resulting *Data Analysis Report* (Annex A) summarises >40 interviews and surveys with municipalities, utilities, NGOs and national agencies, identifying priority data types, functional gaps and user expectations for flood-resilience tools.

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Table of Acronyms

Acronym	Full Term	Description
AIDA	Awareness, Interest, Desire, Action	Communication model used for stakeholder outreach
CC0	Creative Commons Zero	Public domain dedication for data
CEEV	Carpe Europe e.V.	Project partner/NGO
D1.3/ D3.1/ D3.5	Deliverable Numbers	Internal project numbering for deliverables
GDPR	General Data Protection Regulation	EU regulation on data protection and privacy
GFZ	GFZ Helmholtz Centre for Geosciences	Project partner/research centre
GU	University of Gothenburg	Project partner/university
KPI	Key Performance Indicators	Metrics used to evaluate progress
LAPP	City of Lappeenranta	Project partner/ local public authority
LUT	Lappeenranta-Lahti University of Technology	Project partner/university
MOG	Gjøvik municipality	Project partner/ local public authority
NGOs	Non-governmental organisations	Civil society organisations
NTNU	Norwegian University of Science and Technology	Project partner/university
O2.2/ O2.3	Output numbers	Internal project numbering for outputs
SMEs	Small and Medium-sized Enterprises	Business size category
SYKE	Finnish Environmental Institute	National environmental research institute in Finland
WP1.3/WP2	Work Package	Internal project structure naming
A1.3/A2.1/A2.2	Activity numbers	Internal project numbering for activities

1. Introduction: Context and Strategic Purpose

The **BALTFLOODS** project, funded by the **Interreg Baltic Sea Region Programme**, responds to the increasingly urgent challenges posed by climate change-related flooding, stormwater runoff, and the associated risks to urban infrastructure and water quality. With cities across the Baltic Sea Region experiencing greater rainfall variability and more frequent extreme weather events, there is a pressing need to enhance local capacities for real-time monitoring, anticipatory planning, and adaptive mitigation strategies.

To address this need, BALTFLOODS aims to develop, pilot, and transfer **digital and participatory solutions** that strengthen urban resilience and improve stormwater and flood-related phenomena management. These solutions are being co-created by a multidisciplinary consortium of municipalities, research institutions, environmental authorities, and citizen engagement experts. The project places strong emphasis on combining **technological innovation** with **inclusive governance**, thereby ensuring that both systems and communities are better prepared to manage and respond to flood risks.

Both pilot cities in BALTFLOODS face significant but distinct challenges linked to stormwater and runoff management. **Lappeenranta, Finland**, is situated along Lake Saimaa, which serves as both a drinking water source and a recreational landmark. The city confronts a different set of challenges: stormwater and melting snow carry contaminants—such as microplastics, oils, sediments, and nutrients—into the lake, increasing the risk of eutrophication and harmful algal blooms that threaten water quality and public health. In response, Lappeenranta is implementing a Stormwater Management Plan that integrates nature-based solutions—such as urban wetlands and biofiltration streets—with enhanced monitoring and citizen science programs. For instance, implementation of new wetlands along the Pien-Saimaa shorelines in 2023 and biofiltration systems along Koulukatu Street help capture and filter runoff, illustrating active local adaptation. These interventions are coupled with sensor-based monitoring to track effectiveness and integrate data into Lappeenranta's urban system.

Similarly, in **Gjøvik, Norway**, climate change has already manifested in intense rainfall episodes that overwhelm drainage and sewage networks. The city's drainage network combines stormwater and wastewater in certain areas, which means that during heavy rain, the system risks **combined sewer overflows (CSOs)**. These events discharge untreated stormwater mixed with wastewater directly into receiving waters, degrading local water quality and increasing nutrient and pollutant loads in sensitive ecosystems. A recent and particularly damaging example was **Storm Hans in August 2023**, which caused widespread flooding across Eastern Norway. Gjøvik was among the cities severely affected: extreme rainfall led to surges in both sewer and stormwater systems, resulting in infrastructure damage, landslides, and sewage overflows into Lake Mjøsa. Events like Hans underscore the dual threat the city faces: immediate hazards to infrastructure and property, and longer-term risks to water quality due to untreated discharges during overflow events. These experiences have reinforced the municipality's recognition of the need for better predictive tools, faster data integration across systems, and real-time situational awareness to respond effectively to future storms of similar magnitude.

Deliverable D1.1 introduces the **Framework for Piloting and Evaluating Solutions**, developed under Work Package 1 (WP1), Activity A1.1. This framework is designed to guide the implementation and evaluation of digital tools and engagement approaches that will be tested during the pilot phase of the project. It serves as a common foundation for the project partners, ensuring consistency across pilot sites while allowing for contextual adaptation based on local needs and capacities.

At the core of the framework lies the integration of **digital infrastructure and citizen participation**, underpinned by open standards and interoperable technologies. To this end, the framework draws on the **FIWARE Smart Water Reference Architecture**, an open-source, modular digital infrastructure widely adopted in Europe for smart city and environmental applications. FIWARE provides the technical backbone of the framework, offering reusable software components and standardised data models that support real-time environmental monitoring, cross-platform interoperability, and scalable deployment across technical systems and administrative boundaries.

However, the BALTFLOODS framework is more than a simple application of an existing architecture. It is a **contextualized adaptation**, tailored specifically to the environmental, regulatory, and social conditions of the Baltic Sea Region. While it builds on the foundational principles of FIWARE—particularly its support for real-time context data, IoT integration, and open standards—it also addresses the **place-based challenges** that cities in this region face, including legacy infrastructure, limited digital capacity, fragmented data systems, and diverse stakeholder environments.

Importantly, the BALTFLOODS framework has been **designed with transferability in mind**. It offers a **ready-to-use model** for municipalities and regions that currently **lack their own integrated systems** for flood risk management and stormwater pollution mitigation. Instead of developing a bespoke solution from scratch—often a resource-intensive and technically demanding endeavour—local authorities can adopt and adapt the BALTFLOODS framework to suit their specific needs. This provides a critical starting point for cities with **limited technical expertise, budgetary constraints, or fragmented infrastructure**, enabling them to implement effective solutions more rapidly and at lower cost.

Pilot implementations in cities like **Lappeenranta (Finland)** and **Gjøvik (Norway)** demonstrate how the framework can be applied in diverse urban contexts. These pilot sites differ in their levels of digital maturity, institutional structure, and environmental exposure, yet both benefit from a shared reference model that promotes consistency, interoperability, and knowledge exchange across the project partnership.

By providing a structured yet flexible methodology for solution deployment and evaluation, the BALTFLOODS framework not only supports current pilot cities but also lays the foundation for broader **replication and scale-up** across the Baltic Sea Region and beyond. It ensures that the innovations developed during the project are not confined to a few municipalities, but rather contribute to **a regional ecosystem of smart, resilient, and citizen-inclusive water management**.

1.1. Regulations, regional and local laws

All EU and EEA members follow the European Union's Urban Wastewater Treatment Directive (Tiwari et al., 2025), which also serves as a basis for the treatment of stormwater. The revised version of the Directive demands Member States to ensure that the pollution resulting from stormwater overflows does not account for more than 2% of the wastewater load collected annually (Directive 2024/3019). Additionally, wastewater plans should include practices to reduce the pollution resulting from stormwater overflows and collected urban runoff, such as those of first rains following long dry periods. The Directive also suggests the use of sustainable (green) infrastructure over traditional (grey) infrastructure. Countries are then responsible for implementing the Directive into their regional and local laws and regulations.

In Finland, the latest revision of the Land Use and Building Act (LUBA 132/1999) introduced a chapter addressing stormwater management. Under the Act, municipalities are responsible for stormwater management and responsibilities include the development of a stormwater management plan (City of Helsinki, 2018), detention of stormwater at the source, the prevention of the environmental impacts caused by stormwater, taking climate change in consideration, and the phase out of the practice of directing stormwater into wastewater sewer systems. The same is stressed by the Flood Risk Management Act (FRMA 610/2010). On a local level, Lappeenranta has a stormwater management plan developed by Ramboll Oy (LAPP, 2021). Objectives in the plan cover the reduction of flood risks, the protection of groundwater resources, the quality of runoff entering lake Saimaa and other water bodies, and the promotion of nature-based solutions. The plan also outlines the responsibilities of different departments and provides area-specific guidance based on catchment characteristics such as soil type and receiving waters.

The Norwegian Ministry of Climate and Environment's report on stormwater in cities and towns (Norwegian Ministry of Climate and Environment, 2015), extensively covered issues arising from stormwater, and recommendations on how to better implement stormwater management plans locally with information on legal and economic instruments existing in the Norwegian legislation. Following the report, the Planning and Building Act gave authority to planning and building departments to demand that building owners arrange measures to deal with stormwater in new buildings or in those under construction (Norwegian Ministry of Climate and Environment, 2025). Two White Papers (Norwegian Ministry of Climate and Environment, 2013) and (Norwegian Ministry of Climate and Environment, 2023) on climate adaptation also addressed the need for stormwater management plans implementation, including the future implementation of a stormwater fee. On a local level, Gjøvik has adopted municipal guidelines for stormwater management (MOG, 2022), which apply to development projects affecting stormwater runoff. The guidelines require local stormwater solutions which prioritize infiltration and detention, with planning integrated early in zoning and building processes as by the Act.

In parallel, the General Data Protection Regulation (GDPR) shapes how citizen-contributed data can be collected and used. Under Article 4 of the GDPR (European Union, 2016), personal data is defined broadly to include any information relating to an identified or identifiable person—such as a name, identification number, location data, online identifiers, or characteristics tied to a person's physical, physiological, economic, or social identity. Where such data is collected (for example, when citizens submit geotagged observations or photos), explicit and informed consent is required (Articles 4(11) and 7). This ensures that citizen participation is not only effective but also compliant with European data protection standards.

2. Conceptual Overview of the BALTFLOODS Framework

The **BALTFLOODS framework for piloting and evaluating digital solutions**, outlined in Figure 1, is structured to serve as both a practical tool for the project's pilot cities and a transferable reference model for other municipalities across the Baltic Sea Region. It recognizes that building flood resilience and addressing stormwater runoff pollution cannot be approached solely as a technical challenge. It requires an integrated, socio-technical perspective—one that brings together robust digital tools, informed and engaged communities, and a solid foundation of data governance and interoperability.

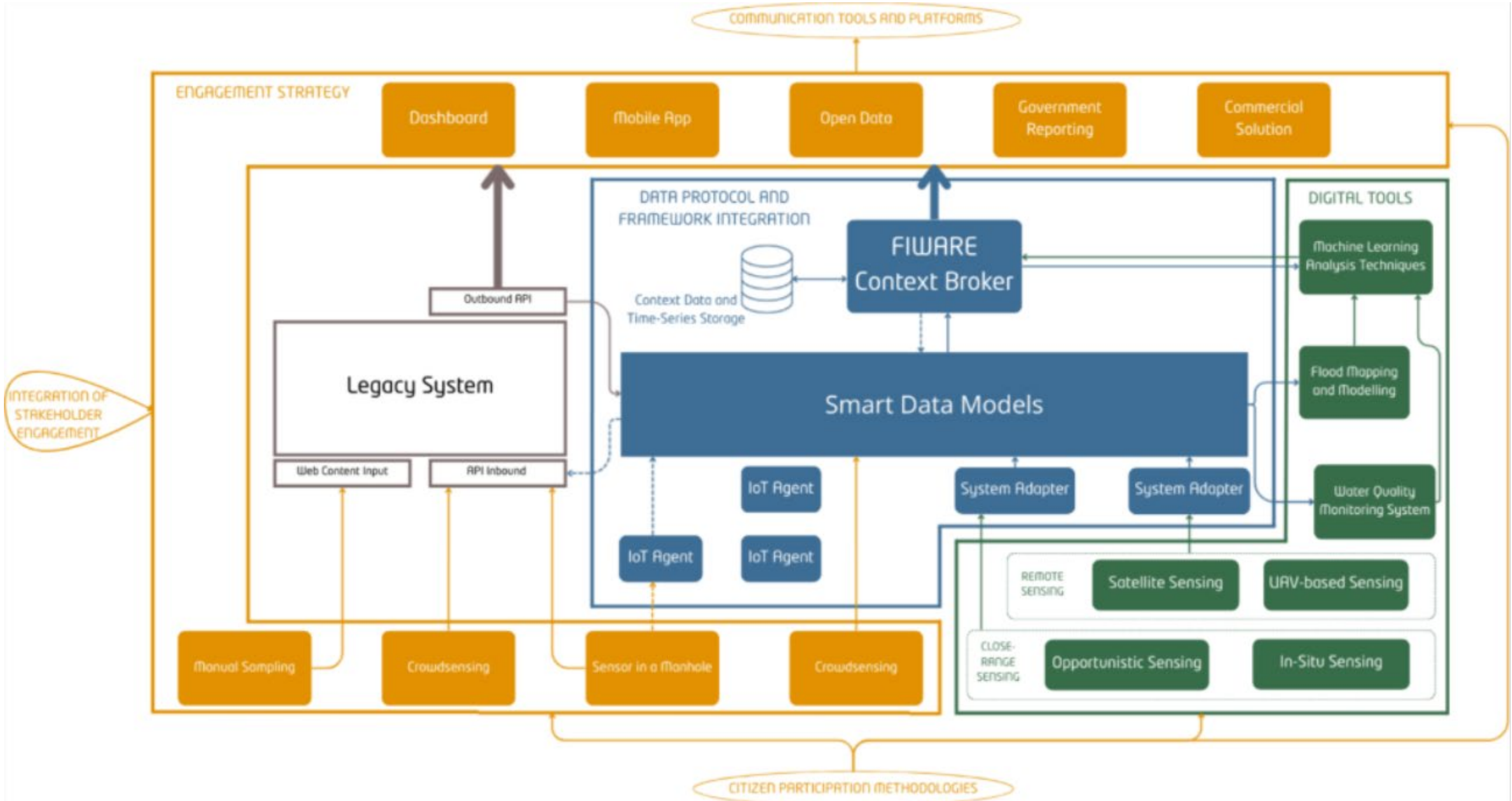

Figure 1. The BALTFLOODS framework for piloting and evaluating flood preparedness and runoff pollution mitigation solutions, structured around three interconnected pillars: (1) Engagement Strategy, ensuring active participation of citizens, stakeholders, and interest groups; (2) Remote Sensing-Based Digital Tools, providing real-time monitoring and modelling capabilities; and (3) Data Protocol and Integration Framework, enabling interoperable, secure, and standardised data flows. The framework is underpinned by a FIWARE-inspired modular architecture, supporting rapid prototyping, integration with existing municipal systems, and scalability across diverse urban contexts in the Baltic Sea Region

The framework proposed in this deliverable reflects that integrated vision. Rather than proposing a rigid or prescriptive system, it introduces a **flexible structure grounded in three interrelated pillars**, each of which addresses a distinct but complementary domain of capability:

1. **Engagement Strategy** – ensuring that citizens and stakeholders are active participants in resilience planning and solution evaluation.
2. **Remote Sensing-Based Digital Tools** – providing cities with actionable insights through real-time environmental monitoring and modelling.
3. **Data Protocol and Integration Framework** – supporting interoperability, privacy, and governance through standardized, scalable data management.

Together, these three pillars offer a **cohesive, multi-dimensional structure** for deploying and evaluating solutions within the BALTFLOODS project. They ensure that pilots are not only technically sound, but also **socially legitimate**, **governance-ready**, and **replicable** across cities with different baseline capacities. By aligning digital tools, community engagement, and data management within a single framework, BALTFLOODS provides municipalities with a **roadmap for action**—one that is grounded in best practice, adaptable to local realities, and open to future innovation.

2.1 Pillar 1: Engagement Strategy

At the core of resilient urban water management is the participation of people—residents, civil society groups, local authorities, and others whose knowledge, behaviours, and decisions affect both risk exposure and response capacity. Recognizing this, the first pillar of the BALTFLOODS framework is built around an **inclusive and structured engagement strategy**, developed by **University of Gothenburg (GU)**, in collaboration with **CEEV, LUT, NTNU**, and **GFZ**.

The goal of this pillar is to foster **active citizen involvement** throughout the project lifecycle—not merely as beneficiaries of digital tools, but as **co-creators and evaluators** of the solutions being piloted. This includes:

- Participatory planning sessions to identify local priorities and co-design intervention strategies
- Community-based monitoring and data contribution through mobile or web-based platforms
- Tailored communication materials to explain risks, foster trust, and enable feedback loops

These methods are designed with **inclusivity and accessibility** in mind. Particular attention is given to engaging groups that are often underrepresented in participatory processes yet are especially vulnerable to the effects of climate change and flood-related disruptions. For example, **children and young people** are reached through schools and educational programmes, both to raise awareness and to enable them to act as multipliers of knowledge within their families. **Elderly residents**, who may be disproportionately affected by flooding and stormwater management issues due to mobility constraints, receive tailored support to help them participate—for instance, assistance in learning to use digital reporting tools, complemented by non-digital participation options such as workshops and printed materials. Other groups, such as recent migrants or communities with limited language skills, are engaged through multilingual communication formats and simplified materials.

By making a special effort to adapt engagement methods—whether through **age-appropriate learning formats**, **digital literacy support**, or **alternative non-digital channels**—the framework ensures that participation is meaningful across different age groups, language backgrounds, and levels of technical competence. This inclusive design not only strengthens the legitimacy of the solutions developed but also ensures that those most exposed to the risks of flooding and stormwater pollution have a direct voice in shaping the responses.

This pillar also explores how citizen-contributed data—such as flood observations submitted via mobile apps or participatory mapping—can be integrated into the broader digital ecosystem using **FIWARE's semantic modelling (NGSI-LD)** and **identity and access management (e.g., Keyrock)**, which enables differentiated data access for citizens, officials, and researchers, and **consent-based data handling**, which ensures GDPR compliance when integrating community-generated data. In this way, community engagement is not merely a parallel process but becomes an active component of the overall data and decision-making framework.

The engagement strategy thus functions as the **social dimension of the BALTFLOODS framework**, directly corresponding to **Pillar 1 in Figure 1**. By ensuring the active participation of citizens, stakeholders, and interest groups, it anchors the more technical components of the framework—namely the digital tools of Pillar 2 and the data integration protocols of Pillar 3—in processes that carry **community legitimacy and lived relevance**. In this way, the engagement strategy does not stand apart from the technical work but provides the participatory foundation upon which the overall framework operates.

2.2 Pillar 2: Remote Sensing-Based Digital Tools

The second pillar focuses on the **digital instruments and analytical systems** that enable cities to monitor, understand, and anticipate stormwater and flood-related phenomena. Developed by technical partners **GFZ** and **NTNU**, these tools harness the power of **remote sensing**, **machine learning**, and **data visualization** to create high-resolution insights into water quality and flood dynamics.

One component of this pillar is the **Water Quality Monitoring System**, which uses data from satellites, drones, and on-site sensors to detect changes in turbidity, pollutant levels, and other key indicators—particularly during or immediately after flood events. By leveraging automated classification and anomaly detection, this system enables faster identification of water contamination and helps inform mitigation strategies.

Another key asset is the **Urban Flood Mapping and Modelling Toolkit**, which integrates remote sensing imagery with local data to generate dynamic flood maps. These visualizations are not only useful for operational response and infrastructure planning, but also provide an intuitive, accessible means of communicating risks to stakeholders and citizens.

By enabling detailed, near real-time understanding of stormwater behaviour, floods, and pollutant dispersion, the tools developed under this pillar serve as essential building blocks for data-informed decision-making. They also align well with the **FIWARE technical foundation**, especially in terms of integrating sensor data through IoT agents and standard data models.

2.3 Pillar 3: Data Protocol and Integration Framework

The third pillar addresses the foundational question of how to manage, standardize, and ethically govern the vast and diverse data flows that underpin smart flood preparedness. As pilot cities and regions implement new monitoring systems, ingest citizen-generated content, and access external datasets (such as weather forecasts or satellite imagery), the need for a **robust data integration layer** becomes paramount.

Under the leadership of **GFZ** and **NTNU**, this pillar develops a **data protocol and governance framework** that establishes consistent formats, secure exchange mechanisms, and clear rules for access, storage, and usage. It addresses critical issues such as:

- **Data interoperability** across systems and platforms
- **Privacy and ethical safeguards** for personal or community-generated data
- **Data quality assurance**, including validation and uncertainty handling
- **Open standards** to ensure scalability and future reuse

This pillar maps directly onto the **FIWARE Smart Water Reference Architecture**, particularly the components related to **context brokering (Orion-LD)**, **time-series storage (QuantumLeap)**, and **standardized data models** such as

`WaterQualityObserved` or `FloodingEvent`. It enables pilot sites to achieve a high level of digital maturity while retaining flexibility to adapt to evolving technologies and local needs.

3. Technical Foundation: FIWARE Smart Water Reference Architecture

In developing the BALTFLOODS framework, one of the earliest and most strategic decisions made by the consortium was to ground the digital infrastructure on a **proven, open-source foundation**—one capable of supporting fast experimentation while remaining adaptable to the complex realities of municipal systems. This is why the project draws directly on the **FIWARE Smart Water Reference Architecture** (FIWARE, n.d.) as its technical inspiration.

FIWARE is not a product or a proprietary platform. It is a **collection of modular, reusable software components**—interoperable by design and available under open licenses—that are widely used across Europe to build smart city and environmental monitoring solutions. These components (known as **Generic Enablers**) are not prescriptive, but flexible building blocks: municipalities can choose which ones to use, configure them based on local needs, and gradually integrate them with existing systems or replace them as more permanent solutions become available.

This **modular and non-intrusive nature** is one of the core reasons FIWARE was selected for BALTFLOODS. Both pilot municipalities—**Lappeenranta (Finland)** and **Gjøvik (Norway)**—have expressed justified concern about the complexity of integrating new systems into their legacy infrastructures. Many public authorities across the Baltic Sea Region face similar challenges: fragmented sensor networks, ageing software platforms, or limited internal IT resources. Often, the source code or integration APIs of these legacy systems are inaccessible or undocumented, making direct integration time-consuming, costly, or technically infeasible.

In this context, attempting to build a completely bespoke or “bottom-up” system would be neither realistic nor efficient. It would require starting from scratch—designing data models, writing middleware, setting up context management layers, and developing dashboards—without any guarantee that the outcome would be compatible with future upgrades or transferable to other cities.

FIWARE provides a practical and future-proof alternative. It gives the project a **ready-made, standards-based prototyping environment** that allows new ideas, tools, and integrations to be tested and evaluated without needing to immediately modify or interfere with existing municipal IT systems. It enables partners to rapidly deploy test environments where new algorithms (such as water quality anomaly detection or real-time flood risk models) can be connected to synthetic or live data, evaluated under realistic conditions, and refined based on local needs.

Crucially, the BALTFLOODS approach positions FIWARE not as a permanent platform that municipalities must adopt wholesale, but as a **development and testing tool**. Once a particular solution or algorithm has been validated through prototyping, it can be **integrated back into the city’s existing environment**, either by reusing the logic outside of FIWARE or by connecting to it via standard interfaces. In this way, FIWARE functions as an **intermediate bridge**—helping cities cross from legacy systems to modern digital solutions without being forced to overhaul their infrastructure prematurely.

At the same time, for those municipalities in the Baltic Sea Region that **currently lack a coherent digital infrastructure** for stormwater management or flood preparedness, the FIWARE-based framework offers a valuable **starting point**. It enables them to adopt a tested, standards-based architecture that is open, adaptable, and aligned with European best practices—without being locked into any single vendor or platform.

Finally, using FIWARE also helps the project achieve **standardization and data compatibility across pilot sites**. Instead of defining data models, APIs, or governance layers from scratch, the framework adopts existing, community-maintained specifications (such as NGSI-LD) that facilitate **interoperability, replicability, and data sharing**. This ensures that the work done in Lappeenranta and Gjøvik can be easily transferred, scaled, or reused by other cities across the region—maximizing the long-term value of the project.

In summary, FIWARE was selected as the technical foundation of the BALTFLOODS framework not because it solves all problems, but because it allows us to:

- **Prototype quickly**, using modular and reusable components
- **Integrate new data sources** with minimal disruption to legacy systems
- **Standardize** how data is structured, processed, and shared
- **Bypass vendor lock-in**, thanks to its open and flexible nature
- And **bridge the digital divide** between cities with mature infrastructures and those just beginning their digital transition.

By enabling this kind of agile, standards-based development, FIWARE supports the project’s ambition to deliver solutions that are not only **technically sound**, but also **realistic, transferable, and scalable** across the diverse municipal contexts of the Baltic Sea Region.

4. Pillar 1: Engagement Strategy

As highlighted in Sections 1–3, **citizen participation is a foundational pillar** of the BALTFLOODS framework. The technical capacity to monitor and model flood risks is only effective when paired with **social legitimacy, trust, and inclusive participation**. To that end, Pillar 1 translates the strategic goals outlined in **Deliverable D1.3 Citizen Engagement Strategy** into an **operational engagement approach** for pilot implementation (WP2) and transfer activities (WP3).

This pillar responds directly to the **participation gaps identified through the stakeholder needs mapping** (see Annex A, Table 1), which revealed several barriers to engagement: lack of accessible channels for input, low visibility of environmental data, and limited citizen involvement in decision-making around nature-based solutions. These gaps are addressed through a multi-layered strategy that blends **citizen science, co-design, and digital engagement**—all supported by the FIWARE-based data infrastructure described in Section 3.

By embedding the engagement strategy deeply into the BALTFLOODS framework, this pillar not only increases public trust and awareness, but also **enhances data quality, improves decision-making, and strengthens social resilience**. While not part of the core FIWARE platform, the **engagement strategy is powered and enabled by FIWARE's infrastructure**—from identity management to data modelling—demonstrating how technical and social innovation can reinforce one another in a cohesive, smart, and inclusive water management system.

4.1 Citizen Participation Methodologies

The BALTFLOODS engagement strategy is built on the recognition that strengthening flood resilience requires not only technical innovation but also **active involvement of citizens, stakeholders, and local associations**. Engagement is therefore framed as a core dimension of the overall framework (see Figure 1, Pillar 1), ensuring that the tools and data developed in the project are grounded in social legitimacy and community relevance.

In practical terms, the methodology combines three established modes of participation—**contributory, collaborative, and co-created approaches**—to create a continuum that links citizen science with co-design. In the contributory mode, citizens and local actors contribute structured observations (for example through the Citizen Engagement App). In the collaborative mode, residents, NGOs, and interest groups interact with data and share interpretations. Finally, in the co-created mode, stakeholders and municipalities work together to shape service concepts and prioritise interventions. The details of these methods, including their design and operationalisation, are set out in **Deliverable D1.3 (Citizen Engagement Strategy)**.

Rather than repeating those methodological details here, this deliverable highlights the **aspiration and role** of engagement within BALTFLOODS. Participation is not limited to individual citizens but extends to schools, elderly groups, NGOs, and other associations—groups that are both underrepresented and especially sensitive to climate impacts such as flooding. Their involvement in **WP2.2 (Piloting)** will be crucial, as it ensures that the technical solutions tested in Lappeenranta and Gjøvik are not only operationally effective but also socially inclusive and responsive to lived experience. By adopting this layered and inclusive engagement methodology, BALTFLOODS strengthens both the legitimacy and the replicability of its solutions across the wider Baltic Sea Region.

4.2 Communication Tools and Platforms

To operationalize this inclusive engagement model, BALTFLOODS implements a layered communication and participation infrastructure that reaches beyond conventional resident-focused outreach. The tools and platforms used throughout the project are designed to engage **a full spectrum of actors**, from residents to environmental NGOs, from school classes to civil protection services, from small business owners to city engineers. This multi-stakeholder approach is essential to building trust, improving coordination, and ensuring that the solutions piloted are relevant and adaptable across different local contexts.

At the heart of this infrastructure is the **Citizen Engagement App (CitySen.app)**, a lightweight, progressive web application released under a CC0 license. The app functions as the central point of access to real-time environmental data, supports structured submission of incident reports, and provides location-aware alerts for events such as heavy rainfall or sewer overflows. In subsequent development cycles, new modules supporting citizen science protocols and participatory co-design activities will be introduced incrementally, using agile six-week sprints to ensure responsiveness to stakeholder feedback and technical feasibility.

To maximize accessibility, the app is developed in compliance with **WCAG 2.1 AA** standards and supports a multilingual user interface, beginning with English and the languages of each pilot city. Where digital access remains limited, **non-digital outreach methods** are employed, including printed informational materials, school-based exhibitions, and open days' showcasing technical solutions and preparedness activities in the piloting sites. These analog touchpoints ensure that all members of the public—regardless of connectivity, ability, or age—can participate meaningfully in the project.

What sets the BALTFLOODS communication strategy apart is its ability to handle citizen- and stakeholder-generated observations as a **regular and reliable part of the data ecosystem**. Reports such as a flooded street, a blocked drain, or unusual water quality can be structured using open standards (for example, the NGSI-LD data model used in FIWARE) so that they are treated on the same level as sensor or satellite inputs. In some cases, these observations will flow through

FIWARE, where the Context Broker enables municipalities and/or citizens to subscribe dynamically to specific report types and combine them seamlessly with other real-time data streams. In other cases, the same information may be ingested directly by existing municipal legacy systems through their established APIs or dashboards. The key point is that citizen and stakeholder input is not peripheral: regardless of the route it takes—via FIWARE or directly into legacy systems—it becomes part of the formal decision-making process, enabling municipalities to act on it in a flexible and scalable way.

In addition to data interfaces, BALTFLOODS cultivates spaces for **continuous dialogue and exchange**. Real-time polling tools such as Mentimeter are used during in-person and virtual workshops to gauge participant sentiment, explore preferences, and generate rapid feedback loops. Periodic webinars—open to stakeholders across the project region—offer opportunities for mutual learning, project updates, and collaborative planning. A dedicated, moderated online workspace (using either Discord or Microsoft Teams) serves as a more focused environment for student groups, educators, and specialized interest communities to engage with the project over time.

The final layer of the engagement platform ensures that knowledge and outputs are preserved, shared, and reused. Public communications guided by the AIDA (Awareness, Interest, Desire, Action) framework are extended through municipal newsletters, social media campaigns, and the project website. Project-generated materials—such as training kits, infographics, and workshop guides—will be openly published, supporting not only transparency but also **cross-project learning and replication**.

For a comprehensive overview of the communication channels employed in the project—including their intended audiences, formats, and evaluation metrics—please refer to **Deliverable D1.3, Table 5.0: Framework, Implementation and KPIs**. This table details how each tool contributes to the broader engagement strategy and outlines the performance indicators used to assess their effectiveness throughout the project lifecycle.

Through this interconnected system of digital tools, analogue outreach, real-time feedback, and open knowledge sharing, BALTFLOODS delivers a **comprehensive engagement strategy**. It enables participation at multiple levels, from passive observation to active co-design, and across diverse audiences—from individual citizens to institutional stakeholders. By treating these actors not just as end-users, but as essential contributors to system design and evaluation, the project lays the groundwork for solutions that are not only smart, but **socially robust, context-aware, and institutionally embedded**.

4.3 Integration of Stakeholder Feedback

Feedback from citizens and stakeholders in BALTFLOODS is not treated as a one-off exercise, but as a **dynamic process that supports continuous improvement** throughout piloting and transfer. To structure this process, the engagement strategy aligns with the evaluation framework defined in Deliverable D2.4 (Sustainability Rating Method, SRM), ensuring that input is captured at multiple levels and translated into tangible adaptations.

At the most immediate level, **continuous feedback** will be collected through in-app micro-surveys and sentiment ratings within the Citizen Engagement App, monitored by NTNU and the development team to track user satisfaction and trigger quick adjustments where needed. Moving beyond this, **periodic stakeholder reflections** will be organised through after-action reviews with citizens and municipal staff following major rainfall events. These sessions, building on the protocols described in D1.3, will feed into the next development sprint and configuration cycle, updated by both stakeholder input and the project's baseline knowledge and lessons from earlier iterations. Finally, at a broader scale, **structured knowledge transfer in WP3 (A3.2–A3.5)** will bring the solutions to local governments, researchers, national authorities, schools, and citizens. Here, feedback will highlight operational fit, scientific robustness, regulatory implications, and social acceptance, ensuring that solutions are tested across diverse contexts.

Together, these feedback horizons ensure that BALTFLOODS solutions remain **responsive, participatory, and replicable**. By embedding learning loops into daily use, pilot evaluation, and transnational transfer, the project creates a framework where citizen and stakeholder perspectives actively shape both the technical outputs and their long-term applicability across the Baltic Sea Region.

5. Pillar 2: Remote and Close-Range Sensing-Based Digital Tools

Two principal digital tools will be developed under BALTFLOODS WP2 by GFZ and NTNU: the Water Quality Monitoring System and Flood Mapping and Modelling Tools. Both are powered by advanced remote sensing, in-situ monitoring, opportunistic environmental sensing technologies (De Vos et al., 2020; Allamano et al., 2025), and machine learning and automated analysis techniques.

5.1 Water Quality Monitoring System

This system fuses satellite-based, UAV-based, and terrestrial sensing platforms to observe, predict, and map changes in key water quality indicators such as turbidity, chlorophyll-a (Chl-a), total suspended solids (TSS), temperature, coloured dissolved organic matter (CDOM), and the presence of surface pollutants—particularly during and after flood events (Rahat et al., 2023).

Satellite missions such as Sentinel-2 (Saberioon et al., 2020; Saberioon et al., 2023), Landsat, PRISMA, and DESIS provide foundational multispectral and hyperspectral datasets. These are calibrated through robust preprocessing workflows, including atmospheric correction, radiometric normalization, geometric alignment, and cloud masking. Processed satellite data enable spatial mapping of parameters like turbidity and chlorophyll concentration across lakes, rivers, and nearshore urban waters (Deng et al., 2024).

These spaceborne observations are supplemented by UAV-based surveys using RGB, multispectral, and thermal cameras. UAVs provide flexible, high-resolution, on-demand monitoring, especially valuable for small-scale or rapidly evolving pollution events. They also serve an important validation role: while Sentinel-2 optical data is powerful for assessing turbidity and chlorophyll, it is limited under heavy cloud cover; and while SAR imagery can penetrate cloud and detect surface water dynamics, it struggles to resolve water quality indicators in urban environments where building geometry creates noise. In such cases, UAV flights can fill the gaps by delivering fine-scale observations that overcome these constraints. UAV campaigns are, however, weather-dependent and require local deployment capacity, making them most effective as a complement to, rather than a replacement for, satellite-based systems. By combining these sources, BALTFLOODS ensures that monitoring strategies remain robust across a variety of environmental and operational conditions.

Terrestrial sensing platforms—such as rooftop or pole-mounted RGB and hyperspectral cameras—extend monitoring capabilities to the local level (Miglino et al., 2024). Positioned above the water surface, these installations offer continuous observation of nearshore zones, allowing for real-time detection of short-term changes such as sediment plumes, algal blooms, or combined sewer overflows. For example, fixed-point systems like the HYperspectral Pointable System for Terrestrial and Aquatic Radiometry (HYPSTAR) have shown strong performance in collecting high-resolution spectral data suitable for near real-time water quality assessments (Goyens et al., 2022).

In addition to these structured deployments, in BALTFLOODS, **opportunistic sensing** is used to supplement structured observations with incidental visual records of turbidity, flooding, or contamination events. Opportunistic sensing leverages everyday devices and public infrastructure—such as CCTV networks, traffic cameras, or citizen-uploaded mobile phone images—to gather environmental information in a non-dedicated but adaptive way (Jiang et al., 2019; Yan et al., 2023). These images can be archived, geotagged, and, where appropriate, processed for simple metrics such as surface water colour or visible signs of pollution (e.g. foaming or discoloration). In doing so, opportunistic sensing provides an additional layer of redundancy and responsiveness, particularly valuable during storms or emergencies when traditional sensors may be offline or outside the affected area.

At the same time, this approach presents challenges. Image quality can vary due to lighting, resolution, or weather conditions; camera orientation often favours traffic or security rather than water surfaces; legal and privacy constraints may limit the reuse of certain data streams; and reliable use of these data requires significant automated processing capacity to extract valid environmental indicators at scale. Recognising these constraints, BALTFLOODS will explicitly account for these risks when designing the framework. Opportunistic sensing will therefore serve as a complementary layer to structured monitoring, enhancing coverage and responsiveness while respecting legal, ethical, and technical boundaries.

In environments with limited infrastructure, low-cost RGB cameras equipped with simple pixel intensity calibration methods provide a scalable solution for continuous turbidity detection. These systems, installed at stormwater outlets or retention ponds, support baseline monitoring where higher-end instrumentation is not feasible.

Citizen-contributed observations—submitted through the Citizen Engagement App—also play an integral role. Geotagged photos, visual assessments, and descriptive reports are converted into structured context entities and integrated with other data streams. These community-driven inputs serve both as validation points and as early warnings for emerging issues, thereby enabling municipalities to detect and respond to water quality threats more rapidly and inclusively.

Together, these multi-source, multi-scale observation methods make the BALTFLOODS Water Quality Monitoring System robust, flexible, and context aware. By integrating dedicated sensors, opportunistic inputs, and participatory sensing, the system provides a comprehensive view of urban water quality dynamics, supporting informed decision-making and long-term resilience planning.

5.2 Flood Mapping and Modelling Tools

Flood monitoring under BALTFLOODS combines physics-based modelling, data-driven forecasting, and multi-source environmental sensing to improve flood preparedness, emergency response, and long-term resilience planning in urban settings. The system integrates hydrodynamic simulations based on the shallow water equations with high-resolution digital elevation models (DEMs), supported by real-time data streams from satellite, UAV, terrestrial, and citizen-contributed sources.

Optical and radar satellite imagery—particularly from Sentinel-1 (SAR) and Sentinel-2 (multispectral)—provides critical large-scale observational data (Islam et al., 2025). While SAR imagery ensures all-weather, day-and-night flood detection, optical imagery offers higher spatial resolution, enabling detailed classification of flood extents and land cover. However, both modalities have limitations: SAR is susceptible to distortions in dense urban areas due to building-induced scattering, while optical sensors are constrained by cloud cover and lighting conditions.

To address these gaps, BALTFLOODS incorporates Unmanned Aerial Vehicles (UAVs), which serve as a crucial observational layer (Iqbal et al., 2023). Drones equipped with RGB, multispectral, thermal, and LiDAR sensors deliver centimetre-level resolution data, ideal for mapping water depth, overland flow paths, and affected infrastructure in time-sensitive scenarios. Their rapid deployment and flexible flight paths make UAVs particularly valuable in complex urban catchments like Lappeenranta and Gjøvik, where flooding dynamics evolve rapidly, and conventional data sources may be unavailable or delayed.

Ground-based sensor networks complement aerial observations with continuous, localized data on rainfall, water levels, sewer overflow events, and soil saturation. These in-situ sensors provide high-frequency, time-series data critical for triggering alerts, calibrating models, and validating remote sensing observations.

Data fusion techniques play a central role in enhancing model accuracy. Satellite, UAV, and ground-based observations are merged with topographic and land use data to refine flood extent classification and improve water depth estimation. The combination of broad satellite coverage and detailed drone imagery ensures both macro- and micro-level flood awareness.

An essential feature of the BALTFLOODS system is its integration of citizen-generated observations (Zhu et al., 2024). Residents can report stormwater and flooding through the Citizen Engagement App, uploading geo-tagged photographs, videos, and field notes. These observations may be ingested into the FIWARE-based platform as structured NGSI-LD context entities and directly contribute to situational awareness. They are used to validate model outputs, identify observational gaps, and strengthen participatory governance by making citizens active contributors to environmental intelligence.

The fusion of these data sources not only improves the spatial and temporal resolution of flood monitoring but also democratizes flood risk management. Citizen input complements institutional sensing infrastructure, especially in areas or moments where traditional coverage may be sparse. This crowdsourced layer supports ground-truthing of remote observations, reinforces public trust, and helps prioritize municipal responses based on lived experience.

In sum, the BALTFLOODS flood mapping and modelling suite represents a next-generation, multi-layered solution that merges intelligent modelling with hybrid sensing and participatory data collection. It is engineered to operate under real-time constraints, adapt to urban heterogeneity, and scale to new geographies, providing a replicable digital foundation for resilient stormwater and flood management across the Baltic Sea Region.

5.3 Machine Learning and Automated Analysis Techniques

Machine learning (ML) forms the analytical core of the BALTFLOODS digital framework, enabling intelligent, real-time interpretation of complex environmental data from diverse sources. These techniques transform raw inputs from satellite sensors, UAVs, fixed cameras, IoT devices, and citizen reports into actionable insights that inform stormwater and flood management, pollution tracking, and flood preparedness.

In the domain of water quality monitoring, supervised learning algorithms—including Random Forests, Support Vector Machines (SVMs), and CatBoost regressors—are trained on multispectral and hyperspectral data to estimate key parameters such as turbidity, chlorophyll-a, and total suspended solids (TSS). These models ingest spectral bands from Sentinel-2, Landsat, and PRISMA satellites, and are validated using in-situ reference data provided by municipal partners and citizen-science campaigns. This hybrid calibration approach improves both spatial generalizability and the credibility of remote sensing predictions.

To account for temporal dynamics, the framework integrates sequence-based models such as Long Short-Term Memory (LSTM) networks and Recurrent Neural Networks (RNNs). These architectures learn temporal dependencies in sensor data and satellite-derived indicators, allowing them to forecast short-term changes in water quality—particularly under conditions of heavy rainfall or stormwater overflow. This is particularly valuable for anticipating periods of high ecological stress in receiving water bodies, thereby supporting timely mitigation strategies.

In flood monitoring and prediction, deep learning models enable both spatial classification and dynamic simulation. Convolutional Neural Networks (CNNs) are employed to process satellite and drone imagery, automatically segmenting flooded areas from dry zones and identifying vulnerable infrastructure (Xu et al. 2025a, 2025b). These classifiers are trained on both historical flood events and synthetic images generated through hydrodynamic modelling, enhancing their robustness under different terrain and weather conditions.

Complementing this, neural operator frameworks—specifically Deep Neural Operators (DNOs)—are implemented to simulate the spatio-temporal evolution of floods. Unlike traditional black-box models, DNOs learn functional relationships that govern water flow across heterogeneous urban morphologies. Trained on sequences of rainfall, runoff, and elevation data, DNOs provide fast, accurate predictions of flood spread and depth, making them ideal for real-time alerting and adaptive management.

The BALTFLOODS architecture also supports close-range environmental sensing through lightweight computer vision methods. Real-time image feeds from fixed rooftop or pole-mounted cameras are processed using pixel intensity calibration and regression models to detect localized flooding and estimate turbidity levels in runoff. These opportunistic sensing techniques, while low-cost, significantly expand monitoring coverage—particularly in areas underserved by traditional sensors or remote platforms.

To harmonize inputs across this heterogeneous ecosystem, data fusion and ensemble learning methods are applied. Kalman filters, probabilistic merging, and multi-model stacking techniques combine readings from satellites, UAVs, ground sensors, and citizen observations into a unified, coherent state of the environment. This fusion not only increases reliability and resolution but also supports uncertainty estimation and decision confidence for downstream applications.

Lastly, transparency and explainability are embedded into the ML stack through the use of Explainable AI (XAI) techniques, including SHapley Additive exPlanations (SHAP). These tools provide interpretability by highlighting the most influential variables in a model's prediction—crucial for ensuring trust in data-driven decisions among municipal operators, regulatory authorities, and the public.

Together, these machine learning and automated analysis tools convert the BALTFLOODS framework from a passive data collection platform into an adaptive decision-support system, capable of detecting early warning signals, refining policy interventions, and guiding resilient urban planning. The modular, open-source nature of the analytical layer ensures that it remains extensible—enabling replication across other Baltic cities and alignment with emerging data spaces and AI regulations at the European level.

6. Pillar 3: Data Protocol and Framework Integration

The third pillar of the BALTFLOODS framework ensures that the diverse streams of information generated within the project—environmental sensor networks, municipal information systems, satellite and UAV observations, and citizen-contributed inputs—can be brought together into a **coherent, standards-based digital environment**. This pillar is about overcoming fragmentation between legacy systems, Earth observation platforms, and participatory tools, by adopting common data protocols and governance structures.

The emphasis is on **interoperability and openness**. By building on established standards, such as NGSI-LD and FIWARE Smart Data Models, the project creates a shared "data language" that allows different systems to exchange information without bespoke or proprietary connectors. This not only supports real-time monitoring and retrospective analysis within the pilots but also lays the groundwork for scalability and replicability across other Baltic cities. The integration framework is designed to be **flexible and future-proof**, ensuring that new data sources or tools can be incorporated without redesigning the entire system.

Equally important is the governance dimension. The framework defines responsibilities for data ownership, access rights, update frequencies, and retention policies, applying the principle of being **"as open as possible, as closed as necessary."** Environmental monitoring data will generally be made openly available, while personal data from citizen contributions will be managed under GDPR-compliant safeguards. This dual approach ensures transparency and broad usability, while protecting privacy and maintaining public trust.

Finally, Pillar 3 acts as the **enabling layer** that links the other two pillars of the BALTFLOODS framework. The engagement strategy (Pillar 1) depends on reliable flows of citizen and stakeholder observations, while the remote sensing tools (Pillar 2) generate large volumes of environmental data that must be harmonised and contextualised. By providing the digital infrastructure to connect these elements, Pillar 3 ensures that BALTFLOODS is more than the sum of its parts: it becomes an integrated, adaptive system for flood preparedness and stormwater management.

Detailed technical specifications of the integration architecture—including system components, data flows, and storage solutions—are provided in **Deliverable D1.2 (Data Systems Integration Plan)**.

6.1 Standards for Data Quality and Governance

Ensuring data quality and responsible governance is foundational to the BALTFLOODS integration framework, as the reliability and legitimacy of any downstream analytics or decision-support functions depend directly on the integrity of the underlying data. The framework embeds a multilayered data quality management strategy, beginning at the point of ingestion and extending through long-term archival, access control, and governance structures.

At the ingestion stage, all incoming data—from IoT sensors, satellite platforms, UAV imagery, and citizen reports—undergo initial validation to ensure consistency, plausibility, and adherence to expected units and formats. Automated range checks and anomaly detection routines flag potential outliers or sensor drift, while secure communication protocols (including HTTPS, TLS, and token-based authentication) ensure that data integrity and source provenance are preserved throughout the transmission pipeline.

To harmonize information semantics across diverse sources, the BALTFLOODS framework mandates the use of established FIWARE Smart Data Models. These include standardized definitions for entities such as `WaterQualityObserved`, `FloodingEvent`, `Valve`, `WeatherObserved`, and `IncidentReport`, ensuring interoperability across sensors, citizen tools, municipal systems, and third-party applications. Additionally, the integration of Common Alerting Protocol (CAP) elements enables compatibility with national and EU-level early warning systems.

The framework defines a detailed set of data quality dimensions:

- **Accuracy and Calibration:** Sensors must be calibrated to certified standards, and remote sensing indices validated with in-situ ground truthing.
- **Resolution and Precision:** Spatial, temporal, and thematic resolution must meet the requirements of the analytical use case (e.g., sub-daily temporal granularity for rainfall sensors).
- **Completeness and Continuity:** Mechanisms are in place to detect data gaps and enable recovery procedures or fallback sourcing.
- **Timeliness:** Real-time or near-real-time updates are prioritized, especially for flood alerts and overflow detections.
- **Reliability and Validation:** Redundancy checks and cross-source triangulation (e.g., citizen photos vs. official water level logs) support robust validation.

Data governance protocols clearly designate ownership, stewardship, and responsibilities throughout the data lifecycle. Each data stream is associated with a responsible partner—municipalities for operational sensor networks, research institutions for analytical modules, and project coordinators for cross-cutting services. Data stewardship responsibilities are formalized through written agreements and will transfer to city authorities after the project's conclusion to ensure long-term sustainability.

A tiered access model balances openness with privacy and security. Non-personal environmental data (e.g., rainfall measurements, turbidity levels) are published under open data licenses to encourage reuse, transparency, and innovation. By contrast, data containing personal information (e.g., geotagged citizen photos or app user accounts) are stored separately, encrypted, and access controlled. Anonymization techniques, such as blurring identifiable features in images and separating metadata from payloads, are applied to minimize privacy risks. The system adheres strictly to GDPR principles, including informed consent, data minimization, and purpose limitation.

All APIs exposing data for internal or external use are documented using open standards such as Swagger/OpenAPI, and data services are offered in both RESTful and subscription-based modes. This facilitates automated data exchange with existing city dashboards, scientific analysis platforms, and EU-wide resilience systems like WATERVERSE and EFAS. The combination of robust quality assurance procedures, a governance-first philosophy, and open interoperability positions BALTFLOODS as a replicable model for integrated stormwater, flood, and environmental data management across the Baltic Sea Region and beyond.

6.2 Integration and Interoperability Mechanisms

Interoperability forms the operational backbone of the BALTFLOODS framework, ensuring that disparate system components—ranging from field-deployed IoT sensors and municipal databases to citizen-facing applications and EU-level platforms—function cohesively as part of a unified digital ecosystem. This integration is enabled through adherence to open standards, modular design principles, and a robust semantic interoperability layer powered by the FIWARE NGSI-LD specification.

At the core of the architecture lies the **Orion-LD Context Broker**, which serves as the centralized conduit for context data exchange. All incoming data streams—whether from hydrological sensors, meteorological APIs, UAV-derived flood maps, or community-submitted incident reports—are represented as structured NGSI-LD entities. These entities adopt harmonized Smart Data Models from the FIWARE ecosystem, including `WaterQualityObserved`, `FloodingEvent`, `OverflowSensor`, and `CitizenReport`, among others. This semantic consistency ensures that applications subscribing to context updates can interpret and process data in a standardized manner, regardless of the originating source or pilot location.

The framework's **modular architecture** enables each component—data ingestion, transformation, analytics, visualization, and external API exposure—to operate as a self-contained module, communicating through defined interfaces. This separation of concerns enhances maintainability and scalability, allowing modules to be upgraded, replaced, or extended independently. It also supports flexible deployment across heterogeneous municipal IT infrastructures.

Legacy system integration is achieved through lightweight adaptors and middleware layers that map proprietary data formats (e.g., CSV exports from Gjøvik's SCADA system or JSON feeds from Lappeenranta's StreetAI dashboard) into the NGSI-LD schema. These transformations can be performed in batch via ETL scripts or in real time using streaming connectors.

To facilitate timely response and automation, the architecture embraces **event-driven paradigms**. The Orion-LD broker supports NGSI-LD subscriptions, enabling downstream systems—such as emergency alert platforms or decision dashboards—to receive instantaneous notifications when specific conditions are met (e.g., water levels exceeding thresholds, turbidity surges, overflow detection). This push-based model reduces latency and improves operational readiness.

Interoperability extends beyond project boundaries. BALTFLOODS ensures alignment with **transnational data-sharing initiatives** by supporting the Common Alerting Protocol (CAP) for flood alerts and adopting spatial standards such as INSPIRE-compliant GeoJSON and WMS/WFS for geospatial services. These capabilities enable smooth integration with higher-order platforms like the European Flood Awareness System (EFAS), WATERVERSE, and emerging Baltic Sea regional data spaces.

All system interfaces are documented using **OpenAPI (Swagger)** specifications, facilitating external use by developers, municipal IT teams, and academic partners. This transparency promotes data democratization and paves the way for replicability in non-pilot cities.

Crucially, the interoperability strategy of BALTFLOODS is designed for **sustainability**. By building on open-source, vendor-neutral technologies and internationally recognized standards, the system avoids technical lock-in and remains adaptable to evolving municipal needs. Whether integrating new sensors, responding to updated regulations, or scaling to additional urban contexts, the framework ensures long-term relevance through its principle of “interoperate, don’t isolate”.

7. Evaluation of the Framework

7.1 Performance Indicators and Metrics

Evaluation is a key element of BALTFLOODS, ensuring that both technical and social dimensions of the project are assessed systematically. At this stage, however, it is neither realistic nor credible to present a full set of indicators with fixed target values. Before doing so, the project must first establish **baseline values** and collect data from pilot deployments. Only then can performance thresholds and targets be defined in a way that reflects real operating conditions rather than abstract assumptions.

Pilots will be evaluated as described in **Chapter 4.3 Monitoring and Evaluation Approach of Deliverable D1.4**. Indicators for each pilot (summarised in Table 3 of D1.4) have already been **pre-identified**, though they are not yet tied to specific targets. The data collected during WP2 may include both baseline and non-baseline information. As pilots advance, the indicator list will be **updated and refined** based on baseline data and insights gathered through ongoing monitoring activities.

For example, in the **Water Quality Monitoring System (Pilot 1)**, performance categories include pollution detection capability, spatial coverage, and system durability. Indicators may cover pollutant concentration, average uptime, transmission success rate, integration capability, and data accuracy, alongside financial viability (investment, maintenance, and operation). In the **V-overflow Modules (Pilot 2)**, evaluation will consider overflow control performance, climate resilience, and ease of maintenance, with indicators such as reduction in overflow events, uptime, installation time, and accuracy. The **Data Management Platform (Pilot 3)** will be assessed for system interoperability, real-time analytics, and scalability, with example indicators including API response time, latency, integration with external systems, and user satisfaction. Finally, the **Citizen Application (Pilot 4)** will focus on user engagement, reporting impact, and accessibility, with indicators linked to participatory activities (e.g. open days, webinars, social media reach) and transfer outputs such as the Best Practice Handbook.

In parallel, indicators linked to **user engagement** are being developed in connection with **D1.3 (Citizen Engagement Strategy)**. These include metrics on levels of citizen and stakeholder participation, satisfaction, inclusivity, and diversity of engagement.

Beyond technical and engagement aspects, BALTFLOODS will also define **Outcome and Impact Indicators**, which look at the tangible environmental and societal benefits generated by the pilots. These may include reductions in combined sewer overflows or surface flooding events, improvements in water quality compliance, and faster emergency response times. On the social side, impact will be tracked through changes in public awareness of flood risks, evidence of behavioural shifts in stormwater management, or references to BALTFLOODS outputs in local planning documents and policies. These outcome measures are particularly dependent on establishing baselines, since progress can only be meaningfully assessed relative to initial conditions in each pilot city.

Finally, the project will include **Transnational and Replication Indicators** to measure its value beyond the pilot sites. These will assess, for example, how many of the tools or methods developed in Lappeenranta and Gjøvik can be transferred to other municipalities, how well the documentation and modular design of the system support replication, and the extent of knowledge exchange across the Baltic Sea Region. Evidence will also be drawn from WP3 activities, such as participation in transfer workshops, uptake by follower cities, and references to BALTFLOODS methodologies in regional or national guidance.

7.2 Performance Indicators and Metrics

To evaluate performance and gather data, the BALTFLOODS project will utilize a comprehensive suite of monitoring and assessment tools. The technical foundation of this framework relies on automated system monitoring, including platform analytics dashboards and extensive logging to track system health, sensor connectivity, data throughput, and error rates in real time. This quantitative data is then processed using advanced analytical tools. GFZ and NTNU will employ Geographic Information Systems (GIS) to visualize and assess spatial information, such as comparing predicted and observed flood extents, while statistical software like Python or R will be used for numerical analysis of performance indicators. For predictive components, machine learning evaluation tools will measure model accuracy. Complementing this technical data gathering is a robust approach to collecting human-centric feedback through online and offline surveys, in-depth interviews, focus groups, and participatory stakeholder workshops. To ensure the integrity of the data, field assessment tools, such as post-event site inspections and auditing checklists, will be used to ground-truth digital information against physical reality.

7.3 Risk and Impact Assessment

BALTFLOODS employs a proactive and comprehensive strategy for managing risks and evaluating project impacts. From the outset, a detailed risk analysis was conducted, identifying potential challenges across operational, technical, financial, regulatory, social, and environmental domains. Mitigation for these risks is integrated into the project plan in practical ways. For technical risks, redundancies such as duplicate sensors and backup data storage will safeguard against device failure or data loss, while fallback procedures allow municipal staff to temporarily rely on existing legacy dashboards if the new services experience downtime. To reduce software-related risks, iterative testing and staged deployments will be applied so that integration errors can be identified early and corrected without disrupting the pilots. Financial risks are addressed through contingency budgeting, ensuring resources are available for unforeseen procurement delays or additional installation needs. Finally, regulatory risks—particularly those linked to GDPR—are managed through early legal consultation and data protection planning, for example in handling citizen-contributed photos or geolocated reports. To address societal risks such as low citizen uptake or stakeholder resistance, the project emphasizes co-creation, user-friendly design, and a clear communication strategy. Environmental risks are minimized by using safe hardware and non-disruptive installation protocols. All identified risks are catalogued in a risk register, maintained by the project coordinator as part of the internal project management toolkit. This register is a living document that records each risk together with its likelihood, potential impact, responsible partners, and mitigation measures. It is reviewed and updated periodically by the consortium—typically at project management meetings or after major events—so that mitigation strategies can be adapted in real time. This process ensures that risk management is not a one-off exercise but a continuous practice, keeping BALTFLOODS resilient and on track to achieve its objective.

Beyond managing potential setbacks, the project is committed to a thorough assessment of its broader impacts. This evaluation extends across multiple dimensions: environmentally, by quantifying reductions in polluted runoff; socially, by measuring changes in community safety perceptions and empowerment through surveys and testimonies; economically, by estimating avoided flood damages and performing cost-benefit analyses; and institutionally, by documenting shifts towards a more data-driven, collaborative culture within city departments. The findings from this multi-faceted impact assessment, combined with insights from risk monitoring, create a crucial feedback loop for adaptive management. For example, if low citizen engagement is identified as a realised risk, the project can implement targeted mitigations and subsequently measure the positive impact of the intervention. All findings, including unexpected outcomes and lessons learned, are documented to maximise the project's success, ensure its long-term sustainability, and contribute a valuable, evidence-based model for other cities in the Baltic Sea region and beyond.

Conclusion

The BALTFLOODS framework presented in this deliverable provides a **practical, scalable, and adaptable structure** for piloting and evaluating solutions to enhance flood preparedness and reduce runoff pollution in urban environments across the Baltic Sea Region. Built on three mutually reinforcing pillars—**Engagement Strategy**, **Remote Sensing-Based Digital Tools**, and **Data Protocol and Integration Framework**—the approach recognises that climate resilience is as much a matter of **people and governance** as it is of **technology and data**.

A key strength of the framework lies in its **FIWARE-inspired technical foundation**, which offers an open, modular, and standards-based set of components for rapid prototyping and seamless integration of new data sources. This approach addresses the specific concerns of municipalities with existing legacy systems, allowing them to test and refine new solutions without the need for deep modifications to their current infrastructure. Solutions that prove effective can be integrated into their operational environments, effectively "bypassing" FIWARE once validated. At the same time, for municipalities without an established digital infrastructure, the framework offers a **ready-made starting point**, avoiding the need to develop complex software components from scratch.

The **Engagement Strategy** ensures that citizens, stakeholders, associations, and interest groups are active contributors to the process, not passive recipients of information. By embedding participatory methods into the framework's operational design, the project enhances both the legitimacy and effectiveness of the solutions piloted. The **Remote Sensing-Based Digital Tools** provide accurate, timely, and actionable environmental insights, enabling more informed decision-making. The **Data Protocol and Integration Framework** guarantees interoperability, data quality, and ethical compliance, ensuring that the information flows are secure, standardised, and reusable across different contexts.

Beyond its technical and methodological components, the framework is designed for **transferability and replication**. Its modular nature means it can be tailored to the needs and capacities of different municipalities while still maintaining compatibility with shared data models and best practices. This makes it a valuable resource not only for the BALTFLOODS pilot cities—Lappeenranta and Gjøvik—but for any urban area in the Baltic Sea Region facing similar challenges.

The next phase of the project will put this framework into practice through **piloting and evaluation activities** (WP2), generating evidence on its performance, scalability, and adaptability. The lessons learned will feed directly into the **transfer activities** (WP3), ensuring that other municipalities can adopt, adapt, and benefit from the solutions developed. In doing so, BALTFLOODS will contribute not only to the resilience of individual cities but also to a **regional ecosystem of smart, citizen-inclusive water management**, capable of responding to the growing challenges of climate change.

Annexes

Annex A: Report on findings from interviews

Annex B: Data Management Plan

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Towards flood resilient cities powered by data and people.

This project is co-funded by the European Union through the Interreg Baltic Sea Region Programme.

BALTFLOODS, Baltic Flood Resilience and Digital Solutions

D 1.1 Annex A:
Report on Findings from Interviews

JUNE 25, 2025

Interreg
Baltic Sea Region

Co-funded by
the European Union

RESPONSIVE PUBLIC SERVICES
BALTFLOODS

This project is co-funded by the European Union through the Interreg Baltic Sea Region Programme.

About BALTFLOODS Project

BALTFLOODS aims to enhance flood preparedness and mitigate runoff pollution in cities across the Baltic Sea region by leveraging digital and technological solutions and engaging citizens as key stakeholders. The project addresses three main challenges aligned with the thematic scope of Priority 1 of the Interreg Baltic Sea Region Programme, particularly Objective 1.2. Firstly, BALTFLOODS will improve disaster preparedness and response to floods by implementing advanced monitoring systems that provide real-time data for timely interventions, benefiting local and national public authorities, infrastructure owners, and service providers. Secondly, the project will decrease the discharge of polluted stormwater, thus enhancing environmental quality and public health. This involves monitoring water quality through innovative approaches that support environmental and public health goals. Thirdly, BALTFLOODS will increase community engagement in flood and water pollution issues through participatory tools, empowering citizens and educational institutions to take an active role in environmental stewardship. By fostering a well-informed and proactive community, the project builds societal resilience to environmental threats. Transnational cooperation will be essential to facilitate knowledge exchange, policy alignment, and resource pooling to enhance the scalability and sustainability of the solutions, ultimately benefiting urban populations and the Baltic Sea Region ecosystem.

Learn more about the project:
www.interreg-baltic.eu/project/baltfloods

Project Name	**Baltic Flood Resillience and Digital Solutions**
Project No.:	#C063
Submission Date	June 25, 2025
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Executive Summary

As part of the BALTFLOODS project, a series of structured interviews were conducted with key stakeholders across Finland, Norway, Sweden, Latvia and Poland. These stakeholders included municipal governments, national public authorities, environmental agencies, and utility service providers. The purpose was to gather insights into current practices, challenges, and future needs related to four critical domains of the project: Water Quality Monitoring, V-Overflow, Data Protocol and Integration Framework, and Citizen Engagement and Co-design. In addition, tailored questions were created for national-level institutions to address specific insights and regulatory requirements.

The findings highlight varied levels of technical capacity and institutional readiness. Municipalities expressed strong interest in improving citizen participation and local monitoring through user-friendly digital tools, while also pointing out the lack of formal systems for stormwater management. National public institutions emphasized regulatory alignment, data sharing protocols, and the integration of environmental monitoring with public awareness strategies. Utility and technology providers pointed to challenges in customer data access and predictive monitoring, underscoring the need for interoperable systems. Municipalities expressed a desire for co-designed solutions that effectively integrate technical innovation with meaningful citizen participation. Stakeholders called for real-time, geolocated environmental data, intuitive user interfaces, and actionable feedback loops to support planning and emergency response.

These insights directly support the development of Deliverables D1.1–D1.4 by informing the piloting framework, data integration plan, citizen engagement strategy, and implementation plan. By grounding project activities in the lived experiences and operational needs of diverse stakeholders, BALTFLOODS is positioned to create scalable, replicable solutions that enhance climate resilience and community engagement across the Baltic Sea Region. This report provides a synthesis of findings that will shape the next stages of project implementation, supporting more responsive and inclusive flood preparedness systems.

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1. Introduction

The BALTFLOODS project is dedicated to strengthening urban and regional resilience against climate-induced flood risks. A key element of the project is the integration of citizen engagement and co-design practices into technical and institutional systems, ensuring that solutions are not only innovative but also socially relevant and grounded in local realities. Central to this effort is a deeper understanding of stakeholder needs, capacities, and expectations.

To this end, structured interviews were carried out with municipalities, national public authorities, utility providers, and companies across Finland, Norway, Sweden, Latvia and Poland. These discussions explored current practices in Water Quality Monitoring, V-Overflow, Data Protocol and Integration Framework, and Citizen Engagement and Co-design. By analyzing these insights, the project team is better positioned to develop inclusive, adaptable solutions that respond to both technical and social dimensions of resilience. The findings summarized here directly inform the development of implementation strategies, co-design practices, and digital tools in upcoming BALTFLOODS work packages.

2. Objectives

This report serves to synthesize stakeholder input gathered through structured interviews as part of the BALTFLOODS project's engagement actions. The aim is to support project design and decision-making in upcoming implementation work packages by providing grounded, stakeholder-driven insights. Based on the thematic focus areas aligned with BALTFLOODS pilot actions, the objectives of the report are to:

- Summarize the institutional, technical, and participatory needs identified across stakeholders.
- Present concrete findings that reflect different levels of readiness, capacity, and experience among municipalities, national agencies, and utility providers.
- Identify gaps and opportunities for improving data flow, system interoperability, and the effectiveness of citizen contribution.
- Provide strategic insight for the co-design of communication frameworks, data integration models, and engagement strategies tailored to local and transnational contexts.
- Support the actionable contributions to project Deliverables D1.1 to D1.4, helping align future solutions with real-world operational contexts.
- Explore opportunities for collaborative and participatory approaches across institutional and community levels, ensuring alignment with the interests of targeted audiences and stakeholders.

By capturing both operational realities and stakeholder expectations, the report supports the development of effective and scalable solutions tailored to diverse regional contexts.

3. Results

The interview questions were organized around four key thematic areas relevant to the BALTFLOODS project: Water Quality Monitoring, V-Overflow, Data Protocol and Integration Framework, and Citizen Engagement and Co-design. These areas align with the piloting practices of the project: for instance, the City of Lappeenranta is piloting activities related to Water Quality Monitoring, Data System Integration, and Citizen Engagement, while the City of Gjøvik is piloting Water Quality Monitoring and V-overflow system. Stakeholders were selectively asked questions according to their relevance to these domains. Interview responses are summarized in Table 1 below. During the process, specific insights and regulatory requirements were identified from national-level institutions, and tailored questions were added accordingly, Table 2.

Table 1. Responses from stakeholders across the thematic areas

Organization	Type	Country	Water Quality Monitoring	V-Overflow	Data Protocol and Integration Framework	Citizen Engagement and Co-Design
City of Tampere	Municipal government	FI	green	red	green	green
Lappeenranta city	Municipal government	FI	green	red	red	red
Lappeenranta city	Municipal government	FI	green	red	red	red
Lappeenranta city	Municipal government	FI	green	red	red	red
Lahti city	Municipal government	FI	green	red	red	red
Kepice Municipality	Municipal government	PL	green	red	red	red
Augšdaugava municipality	Municipal government	LV	green	green	green	yellow
Finnish Environmental Institute	National governmental research institute	FI	red	red	red	red
Environmental health protection IKS	Intermunicipal public-sector organization	NO	green	red	green	red
Ministry of the Environment	National government ministry	FI	red	red	yellow	red
ELY-keskus	Regional government authority	FI	red	red	red	red
Southeast Finland ELY	Regional government authority	FI	red	red	red	red
LAPP Water Company	Public utility company	FI	red	green	red	red
Wioniq-Piplife	Private company	NO	green	red	green	red
Xepto As	Private company	NO	yellow	yellow	red	red
City of Örebro	Municipal government	SE	green	green	red	yellow
Stormwater & Overflow Survey	?	NO	yellow	green	red	green
Mjøsa Felles Fiskeforening	Association	NO	green	red	yellow	yellow
Greenreality	Municipal program	FI	green	red	red	red
NTNU	University	NO	green	red	red	red
LUT	University	FI	green	red	red	red
Saimaa Water Protection Association, SVSY1	Non-profit association	FI	green	red	red	red
Saimaa water and enviromental research, SVSY2	Non-profit association	FI	green	red	red	red

Color coding in this matrix reflects the completeness of information gathered across four thematic categories. Green indicates most questions were responded, yellow denotes that questions were partially answered, and red signifies no answer obtained for the set of questions.

Table 2. Questions to national public authorities

Organization	Type	Country	Questions to National Public Authority: General questions	Current Situation	Technical and legal regulation	Climate and Future Perspective	Funding and Instruments	Interdisciplinary Cooperatio and Citizen Involvement
Finnish Environmental Institute	National governmental research institute	FI	red	red	red	yellow	red	red
Ministry of the Environment	National government ministry	FI	red	red	red	red	green	red
ELY-keskus	Regional government authority	FI	yellow	green	yellow	yellow	red	green

Color coding in this matrix reflects the completeness of information gathered across four thematic categories. Green indicates most questions were responded, yellow denotes that questions were

Although the number of responses was limited and not all questions were answered by every participant, the findings reveal clear themes that provide strategic insight into local needs and expectations.

Interviews with the city of Lappeenranta and Lahti, universities, and other associations conducted during the TransformAR project were also included in this analysis, as they provide answers to the water quality monitoring set of questions.

3.1 General Findings

The interviews revealed shared concerns across all stakeholders regarding the growing impact of urban and seasonal flooding, particularly where drainage systems are insufficient or maintenance is lacking. Respondents from both urban and rural municipalities described issues such as infrastructure overload during intense rainfall, overgrown ditches, and runoff from agricultural areas. Spring flooding due to snowmelt and fluctuating water levels in rivers were also identified as critical challenges.

Monitoring practices and access to data varied considerably. While a few institutions collect physical indicators like turbidity, conductivity, or water flow, others reported no systematic monitoring at all. Where data is collected, it is often fragmented or outdated, limiting its usefulness for real-time response or preventive action. Stakeholders, including Norwegian partners, underscored the value of real-time, geolocated measurements to detect drainage blockages, rising water levels, and surface runoff patterns. Norwegian interviewees also highlighted the importance of predictive tools and deviations in system capacity to support risk anticipation and intervention planning.

Interviewees identified that the addition of monitoring the following parameters would be useful for their work and responsibilities:

- pH
- Nitrate and phosphate concentrations
- E. coli
- Oxygen level
- Microplastics
- Heavy metals (e.g. copper, zinc from road runoff)
- Oil compounds
- PAHs
- Pesticides
- Water level (above sea level) and levels in drainage ditches and lakes
- Precipitation intensity and frequency
- Duration of water retention after rainfall
- Electrical conductivity
- Deviation in capacity
- Load during recreational use

Some interviewees noted that current engagement practices fall short of utilizing citizens as contributors to environmental monitoring. Public awareness can be rather low, and institutional collaboration with schools, NGOs, or residents is rare. However, some community organizations are actively filling the gap. For instance, the Joint Fishing Association at Lake Mjøsa monitors water clarity and algae blooms, using this data to advocate for better pollution control. Such groups have expressed interest in accessing more real-time data and predictive tools from authorities, indicating an untapped opportunity for collaboration in stormwater monitoring. Answers highlighted a lack of intuitive reporting mechanisms and an absence of visible impact when citizens do provide feedback.

Interviewees from Tampere and Augšdaugava expressed interest in using mobile apps and visual dashboards, which can act as co-design digital solutions and enable better interaction across stakeholder groups. Interviewees expressed support for models that connect public data with actionable tools and community involvement.

Survey feedback from four Norwegian municipalities/utilities (collected in June 2025) reinforces these trends. All respondents affirmed facing stormwater management challenges, and most highlighted the need for better data on water quality (turbidity, E. coli, microplastics, etc.) and more systematic tracking of combined sewer overflows. This convergence of survey and interview insights strengthens confidence in the identified priority areas for BALTFLOODS.

3.2 Interests and Needs

3.2.1 Municipalities

The City of Tampere, Finland, noted that while its existing stormwater systems are more advanced, challenges remain in raising awareness among citizens and activating feedback mechanisms. The city also emphasized the importance of visual tools and clear communication strategies to build public understanding of water systems and infrastructure. These needs reflect the broader demand for user-oriented co-design processes that ensure citizens are informed, motivated, and able to participate effectively in environmental monitoring and resilience-building. The cities of Lappeenranta and Lahti, also located in Finland, collect a range of information of stormwater and water quality of wetlands. While flood areas are known in Lappeenranta, interviewees listed a set of additional information they would like to have about stormwater, some of those needing more advanced equipment than sensors to be collected.

The Municipality of Kępice, Poland, reported frequent stormwater challenges, particularly due to runoff and the lack of structured drainage systems. Flooding during heavy rainfall is common, affecting homes and public spaces. They currently do not operate a formal monitoring system but would benefit from real-time water level data and flow rates. Such data would support both short-term emergency responses and long-term infrastructure planning. Kępice emphasized the need for predictive information that could be used to assess risks to specific buildings and to inform decisions on land use and system upgrades. Their feedback aligns with BALTFLOODS' objective to involve citizens in early flood detection through mobile-based tools and participatory monitoring.

Augšdaugava Municipality, Latvia, likewise does not have a functioning monitoring system in place but showed a clear willingness to participate in solution development. They are particularly vulnerable to spring flooding due to the presence of large rivers and high groundwater levels. Their key interests include co-developing a system to visualize changes in water levels, making results publicly available, and sharing insights across administrative units. Moreover, the municipality expressed interest in engaging schools and local associations in monitoring and awareness activities, pointing to the potential for integrated educational and civic engagement efforts.

The City of Örebro, Sweden added a similar perspective from a Swedish context. Örebro officials noted that while catastrophic floods are infrequent (aside from a notable basement-flooding event in August 2023), stormwater quality is an ongoing concern under strict environmental standards. The city currently has no continuous monitoring system, relying instead on targeted flow measurements and occasional pollutant surveys. This gap points to a desire for improved data: Örebro sees value in deploying continuous flow sensors and additional rain gauges to capture runoff dynamics in real time. They cautioned that critical water-quality parameters differ by location and season, making it difficult to apply universal measures. At present, Örebro shares no stormwater data publicly, though they believe rainfall and runoff information would engage citizens if communicated via user-friendly channels. Their input underscores common municipal needs – better monitoring infrastructure and more citizen-facing information – echoing the calls for solutions that are technically robust yet community-oriented.

Municipalities vary in their technical readiness but share a common interest in participatory monitoring tools, accessible data visualization, and improved citizen engagement. Their needs reinforce the demand for modular, scalable solutions that respond to local contexts while fostering community resilience.

3.2.2 Utility Services and Companies

Utility services and private-sector partners play a crucial role in bridging municipal infrastructure with emerging technologies for water and data management. The Lappeenranta Water Company highlighted its ongoing efforts to upgrade stormwater systems, emphasizing the need for real-time operational visibility and digital integration across departments. The utility provider acknowledged limitations in existing SCADA systems, pointing to the value of sensor-based upgrades that can feed into citywide dashboards and risk alerts. Their interest in data-driven infrastructure supports the BALTFLOODS objective of aligning operational monitoring with public-facing communication tools.

Wioniq-Piplife, a Norwegian company specializing in smart infrastructure, focused on customer-side integration. They advocated for systems that not only monitor technical parameters but also engage end users through intuitive interfaces. For example, their vision includes modular dashboards that can deliver performance insights to both municipal engineers and residents, fostering shared responsibility for flood risk management. The company also noted the potential to integrate pipe system data with public GIS platforms, which could enhance spatial decision-making in urban planning.

Xepto, another Norwegian firm, brought a highly technical perspective to stormwater readiness. They emphasized the importance of capacity deviation tracking—essentially detecting when systems deviate from expected flow or pressure parameters—as a predictive maintenance tool. Their approach combines real-time telemetry with AI-based diagnostics, which could significantly enhance early warning capabilities in BALTFLOODS pilot regions. Xepto expressed interest in piloting scalable monitoring modules that can be adapted across cities with varying levels of digital maturity. Notably, a few survey respondents also identified companies like Xepto and Pipelife as current providers of sensors for stormwater and overflow monitoring, reflecting active private-sector support in this domain.

Together, these companies underscored the need for solutions that are both technically robust and socially accessible. They called for integration protocols that support legacy systems, real-time interoperability, and end-user engagement. Their insights support the BALTFLOODS goal of co-developing inclusive, future-proof tools that connect citizens, utilities, and municipal authorities in a shared resilience strategy.

3.2.3 National Public Authorities

National-level stakeholders offered detailed insights into the regulatory, technical, and systemic challenges that affect stormwater and flood risk management. The Finnish ELY Centre and SYKE (Finnish Environment Institute) underscored issues of fragmented data governance. They noted that water monitoring data, although collected by various actors, is often not accessible in real-time and is constrained by outdated systems and differing data standards. They emphasized the importance of establishing harmonized protocols to improve interoperability between municipal systems and national databases. SYKE also pointed to the growing need for automation and predictive modeling to manage climate-driven risks and highlighted their interest in pilot tools that can scale across municipalities.

The Finnish Ministry of the Environment emphasized the regulatory complexity involved in deploying new sensor-based systems or modifying infrastructure. They recognized the potential for pilot implementation approaches that consider permitting timelines, data privacy, and compliance with environmental directives. Their responses confirmed the necessity of coordinating legal, technical, and community dimensions in co-designing flood resilience strategies.

Norwegian Environmental Health Protection (IKS) provided insights into how national public health and environmental agencies are adapting to incorporate stormwater concerns into their mandate. They indicated readiness to collaborate with municipal actors to expand their scope beyond water quality into runoff-related indicators. IKS also expressed interest in integrating citizen-reported data, provided that validation mechanisms are in place.

The perspectives gathered from national public institutions highlight the critical importance of aligning technical innovation with regulatory standards and systemic integration. The interviews with these actors indicated the need for harmonized data protocols, legally compliant pilot designs, and scalable engagement mechanisms that bridge national oversight with local implementation. Their involvement is essential to ensure that BALTFLOODS outputs are not only effective in demonstrator cities but also transferable across national and transnational policy landscapes.

3.2.4 Non-Profit Associations

Non-profit organizations bring additional input on data quality monitoring. Saimaa Water Protection Association (SVSY1) focuses on evaluating the impacts of agriculture and forestry on wetlands, taking water samples from wetlands, lakes and ditches. Not all tests are performed by the organization, and some parameters such as oils in the water are not currently being tested despite the acknowledged interest for information. Saimaa Water and Enviromental Research (SVSY2) does similar measurements of ditches, bed, rivers, and wetlands, with the additional sampling of pipelines in factory areas. While important parameters are already investigated, others of importance for agricultural areas such as pesticides are not. SVSY2 also expressed interest in investigating the load during recreational use, a parameter not mentioned during other interviews.

3.2.5 Universities

The interviews with LUT and NTNU revealed important insights into current practices, challenges, and opportunities in stormwater management. LUT provided information on measurement practices, such as which parameter can be measured automatically, which should be measured in real time or through samples with more comprehensive analysis. Challenges in measuring oils visible in water were mentioned (e.g. often what looks like oil can be a bacterial population), and cameras and machine vision in oil detection were mentioned as a possible solution that could be developed by both universities. The interview with NTNU revealed technical difficulties in monitoring parameters.

4. Contributions toward Deliverables

The interview findings across municipalities, ministries, research institutes, and technology providers have generated actionable knowledge that can be directly mapped to the four core deliverables of BALTFLOODS' Work Package 1 (D1.1–D1.4). Below is a summary of how these findings can potentially contribute to the development of each deliverable.

4.1 D1.1 – Framework for Piloting and Evaluation

Stakeholder input revealed variability in stormwater monitoring systems, ranging from advanced infrastructure in Tampere to absent systems in Augšdaugava. This diversity enables the development of a flexible evaluation framework sensitive to different baseline capacities and system maturity. Interviewees frequently emphasized the value of real-time and predictive data, for instance, Xepto's focus on capacity deviation analysis, to detect local anomalies, offering parameters for pilot evaluation. These insights inform the performance metrics for pilot testing and evaluation outlined in D1.1, particularly concerning system responsiveness, data usability, and citizen uptake. Additionally, emphasis on co-design and localized relevance supports the development of context-specific evaluation criteria.

4.2 D1.2 – Data Systems Integration Plan

Institutions and companies across Finland, Latvia, and Norway cited challenges related to data fragmentation, outdated monitoring practices, and lack of interoperability. For example, the Finnish ELY Centre highlighted difficulties accessing up-to-date hydrological data from multiple sources, and Wioniq-Piplife emphasized the lack of customer data integration for water systems. These findings guide the development of D1.2 by emphasizing the need for integration protocols that support diverse formats, legacy systems, and real-time updates. Interviews also indicated a demand for dashboards that combine citizen-generated observations with professional data streams, reinforcing the value of flexible data routing systems and unified architecture for futureproofing.

4.3 D1.3 – Citizen Engagement Strategy

The interviews offer limited but critical input for shaping an inclusive, scalable strategy for citizen engagement. Interviewees noted that while citizens are willing to engage, there are few intuitive mechanisms to do so. The City of Tampere noted a gap in public awareness despite sophisticated systems. Augšdaugava municipality expressed a desire to involve schools in data collection and cooperate with local communities and NGOs to disseminate information on flood preparedness. Feedback from citizen associations (like those concerned with water quality in local lakes) will be incorporated to ensure the strategy empowers community monitors and volunteers.

These findings support the design of D1.3 by confirming the importance of: (1) accessible user interfaces (e.g., mobile forms, maps), (2) clear feedback loops (e.g., showing response to citizen inputs), and (3) institutional embedding of engagement processes (e.g., school partnerships). This information also informs training and outreach strategies to be embedded within the strategy document.

4.4 D1.4 – Pilot Implementation Plan

The interviews contribute to D1.4 by identifying specific operational needs, stakeholder roles, and implementation barriers that can shape pilot design. For instance, Norwegian Environmental Health Protection (IKS) showed readiness to extend existing water quality monitoring systems to cover stormwater events, suggesting how pilots could be built upon existing capacity. Meanwhile, feedback from the Finnish Ministry of the Environment emphasized regulatory considerations and the need to streamline permissions for deploying sensors. These findings point to opportunities and constraints that must be accounted for in pilot planning, particularly the importance of involving both data users and regulatory stakeholders early. Interviews also identified key timing windows for implementation, including the spring snowmelt season and summer peak rains, informing seasonal targeting in the activity timeline of D1.4.

5. Conclusion

The interview findings underscore a shared recognition among municipalities, national public institutions, and utility service providers that current stormwater and flood management systems face serious limitations in preparedness, monitoring, and citizen interaction. While technical capabilities vary significantly across stakeholders, from advanced digital tools in urban centers to the absence of any monitoring in smaller municipalities, all actors articulated a strong need for improved data integration, real-time environmental monitoring, and structured citizen engagement mechanisms. National institutions highlighted the importance of harmonized standards and inter-agency coordination, while utilities and companies called for more predictive tools and customer-linked data flows. Despite differences in institutional capacity, a unifying theme emerged: stakeholders are eager to co-develop tailored solutions that are responsive to both operational needs and public expectations.

These insights provide a valuable roadmap for refining the BALTFLOODS implementation strategy and designing the tools and frameworks outlined in Deliverables D1.1 through D1.4. By capturing diverse perspectives and revealing context-specific gaps, the interviews ensure that the upcoming piloting actions will be not only technically sound but also socially inclusive and strategically aligned. Ultimately, this report reinforces the critical role of multi-level engagement and integrated systems thinking in advancing climate resilience across the Baltic Sea Region.

Annex

1. Interview Questions

General Questions for Relevant Stakeholders

Water Quality Monitoring

1. Does your organization have challenges with stormwater? (e.g. quality, flooding)
2. What information do you currently collect/monitor about stormwater (e.g. flow, turbidity, contaminants)?
3. For what purpose do you need information on stormwater quality (/quantity) (e.g. infrastructure planning, pollution control, public health, regulatory compliance)?
4. What additional information about stormwater would you find useful for your work or responsibilities?
5. What measurable values do you see that reveal the information you want to know?
6. Which specific parameters or indicators (e.g. pH, nitrogen, E. coli, microplastics, conductivity) do you think are most important to monitor in your area?
7. Are you aware of any laboratory analytical methods that can measure those parameters/indicators?
8. Do you know of any automatic sensors that can measure those values?
9. Can you list your suppliers of sensors and equipment for stormwater monitoring if you have any?
10. What are your expectations or requirements for data resolution, frequency, or format?
11. Are there measurable thresholds or limits (e.g. regulatory, internal guidance) that are relevant for interpreting those parameters?

V-Overflow

1. Do you have overflows in your pipeline network today?
2. How do you measure overflows today. Number of times with overflow, or number of times and quantity?
3. What are your expectations or requirements for data resolution, frequency, or format?
4. Do you have routines for following up on these measurements?
5. How do you follow up on overflows? Do you report this to the authorities or is it just for internal use?
6. How do you maintain the overflows?
7. Are there any public requirements from the government that there should be measurements on the overflows you have in your stormwater and sewage facilities?
8. Can you list your suppliers of sensors and equipment for V-overflow if you have any?

Data Protocol and Integration Framework

1. What data do you have? (e.g. data sources from cameras, satellites?)
2. What data or information are you currently sharing with the public?
3. What data or information should be shared with the public? What might be interesting?
4. How is the data shared now?
5. What data do you plan to collect and share in the project? Any challenges you foresee when sharing the data in our project?
6. How will you technically share the data. For example, is there some kind of API's that shares the data？Or something else? (Some architecture)
7. Is there any legal framework that allows you to share the data? What rules and laws apply to data sharing.
8. How do you currently reach the interested citizens?

Citizen engagement and co-design

Experience with flooding

1. Have you or someone you know experienced flooding in this city? What happened?
2. What's the biggest challenge you've faced during floods? (e.g., transport, power, safety)
3. Where do you think flooding is worst in our area? Why?

Awareness and local knowledge

1. What do you think are the main causes of flooding here? (e.g., blocked drains, heavy rain, river overflow)
2. Are there early warning systems in place? How do you currently receive flood alerts?

3. Which streets/areas flood first or worst? Why? (e.g., poor drainage, construction)
4. Are there recurring issues during floods? (e.g., sewage backup, power cuts, stranded residents)
5. What kinds of volunteer programs or training would help citizens feel more prepared and empowered to help during floods?
6. What communication channels (social media, community meetings, SMS alerts, etc) would be best reach a wide range of citizens during a flood emergency?
7. What barriers do you think prevent citizens from participating in flood response or pollution prevention efforts and how can we address them?
8. How can we make flood preparedness activities more accessible?

Needs

1. What infrastructure (e.g., drains, pumps, green spaces) is missing or failing in your neighborhood?
2. What info would you need in a flood alert? (e.g., water depth, safe routes, shelter locations)
3. How could technology (apps, sensors) help our community prepare? What kind of features do you need for such apps or sensors?
4. What policy changes would you suggest to local government? (e.g., zoning laws, drainage upgrades)

Citizen engagement and action

1. What would motivate you to join flood-prevention efforts? (e.g., rewards, community pride)
2. Who else needs to be involved? (e.g., schools, businesses, religious groups)
3. What support do you need from authorities/NGOs to make this happen?

Co-design

1. What apps do you use for weather alerts or emergencies? What do you like/dislike about them?
2. When flooding happens, what's the first thing you do to check for updates or report issues?
3. What information do you wish you had during floods? (e.g., real-time water levels, safe routes, emergency contact)
4. How would you like to report floods in the app? Through text, location sharing, photos, or some other ways?
5. Would you like to contribute data? Such as uploading flood photos, marking unsafe areas.
6. Who should verify reports? Such as other users, or government?
7. What successful example have you seen locally or elsewhere of citizen engagement during flood events that we could learn from?

Questions for National Public Authorities

General Questions

1. How many incidents have there been in the last 2 years?
2. Do you have an estimate of the extent of damage and costs?
3. What are the requirements for handling stormwater and are any changes expected in the near future?
4. Do you see any changes in how this will be handled in the future?
5. Will there be any new national regulations or new EU regulations governing this?
6. How will this affect municipalities in the future?

Current Situation

1. How do you assess the current stormwater management in Norwegian municipalities?
2. What requirements are currently imposed on municipalities regarding stormwater in new development projects?
3. How is it ensured that municipalities actually implement the necessary measures?
4. Is the current legislation and regulations sufficient to handle stormwater challenges?
5. How do state actors collaborate with municipalities and private actors to solve stormwater problems?

Technical and Legal Regulation

1. How are considerations for nature-based solutions (e.g., green roofs, rain gardens) balanced with traditional infrastructure?
2. How is the need for changes in the Planning and Building Act assessed for better stormwater management?
3. Are there plans to clarify responsibilities between the municipality, private developers, and other actors?

Climate and Future Perspective

1. How are you preparing for increased rainfall and extreme weather in light of climate change?
2. Are there national goals or strategies for stormwater management towards 2030 and 2050?
3. How do you assess the risk of flooding and stormwater in urban areas in future climate scenarios?
4. What kind of research and knowledge development do you support for future stormwater management?

Funding and Instruments

1. How can municipalities get support to implement good stormwater measures?
2. Are economic instruments being considered to stimulate more sustainable stormwater management?
3. What is your view on introducing stormwater fees as an incentive for local measures?

Interdisciplinary Cooperation and Citizen Involvement

1. How can citizens and private actors contribute more actively to stormwater management?
2. How do you work with interdisciplinary cooperation between planning, environment, and the water sector?

2. Detailed Answers

Interview conducted with the cities and municipalities.

Questions	City of Tampere	Kepice Municipality	Augšdaugava municipality
Does your organization have challenges with stormwater? (e.g. quality, flooding)	Yes, both. Certain catchment areas are more problematic than others in terms of water quality and flooding. Our flood risk is considered low according to the national evaluation tool—mainly involving cases such as water entering yards or basements, particularly in urban areas. One lake in an urban area is problematic, and some areas experience flooding due to rain events related to catchment characteristics.	Yes. The Municipality of Kępice experiences problems related to stormwater, especially during heavy rainfall events. These often result in local flooding – water flows from agricultural fields and floods, among other things, basements and stairwells, particularly in older, pre-war buildings. Additionally, many villages lack stormwater drainage systems, which exacerbates the problem. Drainage ditches are often overgrown and insufficiently clear, preventing them from fulfilling their intended function. During summer, issues also arise with cyanobacterial blooms in Lake Obłęże and with decreasing water levels in Lake Korzybie.	The territory of the Augšdaugava municipality has problems related to flash floods and floods. The municipality is crossed by one of the largest rivers in Latvia — Daugava, as well as other natural water bodies, the rise in those waters during spring floods and after intense rainfall causes significant flooding of territories. The main cause of floods is the rise in water level in natural water bodies and their overflow. In some cases, the problems are also exaggerated by inadequately functioning or outdated drainage systems that are unable to drain excess water from territories effectively enough. Such situations make everyday life difficult for residents and create challenges in maintaining infrastructure.
What information do you currently collect/monitor about stormwater (e.g. flow, turbidity, contaminants)?	Water flow, turbidity, conductivity, and temperature are monitored online at 10–20 stations around the city year-round (not all stations are monitored continuously due to high costs); in streams , select sewer locations and pilot projects. The city has one weather station located in the city center. Additionally, there will be 25 online monitoring for water levels and temperature to detect potential wastewater contamination. At the same time, water samples will be collected to validate the monitoring results.	Currently, there is no ongoing hydrological or quality monitoring of stormwater. Data on the effects of heavy rainfall, such as flooding, are collected by the Volunteer and State Fire Services as part of statistics on "local threats." These data are not separated by type but can be extracted from intervention reports. Regarding water quality – during the bathing season, the quality of water in Lake Obłęże is monitored by the Health Inspectorate (e.g., E. coli, pH, temperature), in accordance with bathing regulations. In the town of Kępice, water discharged through the stormwater drainage system is tested once a year for suspended solids and petroleum substances.	Monitoring activities are not carried out.
For what purpose do you need information on stormwater quality (/quantity) (e.g. infrastructure planning, pollution control, public health, regulatory compliance)?	Mainly for stormwater planning—for sizing and modeling stormwater systems, and also for pollution control (the environmental protection department is responsible for checking if there are any issues); identifying the problems and taking action	This data is needed for several purposes: • To plan investments in drainage infrastructure (e.g., stormwater systems, ditches, reservoirs), • To reduce flood risk and protect residents, • To monitor water quality in lakes and bathing areas (cyanobacteria, pollution), • For environmental protection and climate change adaptation, • For regulatory compliance (e.g., Health Inspectorate, Polish Waters, Water Framework Directive), • To improve the efficiency of emergency and crisis response services.	With the aim of identify and manage the situation in the municipality, identifying existing and potential risks, planning effective infrastructure, choosing suitable rainwater collection, treatment and drainage solutions (for example, green infrastructure or filtration systems). More detailed information allows the municipality to operate more efficiently, prevent risks and promote sustainable development of the territory, and integrate the obtained data into spatial planning.

What additional information about stormwater would you find useful for your work or responsibilities?	Need more weather stations in the eastern and western parts of the city due to thunderstorms and localized rain events during the summer. Currently, we only have one station in the city center that monitors precipitation and temperature. A turnkey service should be prepared	Useful data would include: • Water levels in drainage ditches and lakes, • Intensity and frequency of precipitation, • Volume of surface runoff from agricultural fields, • Stormwater quality (e.g., nitrate and phosphate content), • Duration of water retention after rainfall, • Changes in water levels during drought (e.g., Lake Korzybie).	Currently, no specific additional information on stormwater needed in the daily work of the municipality. However, taking into account the impact of climate change and increasing risks of precipitation intensity, such information may become more relevant in the future, especially in the context of infrastructure planning and risk management.
What measurable values do you see that reveal the information you want to know?	Phosphorus (limited technology for online monitoring); microplastics	We would like to obtain measurable values such as: • pH, • Nitrate and phosphate concentrations (mg/l), • E. coli count (cfu/100 ml), • Water level (cm or m above sea level), • Rainfall intensity (mm/h), • Electrical conductivity (µS/cm – general pollution indicator), • Turbidity (NTU).	No answer can be provided at this time.
Which specific parameters or indicators (e.g. pH, nitrogen, E. coli, microplastics, conductivity) do you think are most important to monitor in your area?	Conductivity is important as it already gives some indication about water quality, and you can use it to calculate phosphorus levels. In some areas, we also want to monitor nitrogen — it's important especially in eutrophic lakes. And then of course, sometimes you have pollution or contamination from wastewater, for example, due to old sewer systems, which can lead to wastewater entering streams (if any coliform bacteria).	The most important parameters are: • pH – affects cyanobacterial growth, • Nitrates and phosphates – indicate fertilizer runoff from fields, • E. coli – essential for bathing water safety.	For example, pH, electrical conductivity, Ammonium ions (mg/l NH4-), Biochemical oxygen demand BOD5(mg/l O2)
Are you aware of any laboratory analytical methods that can measure those parameters/indicators?	We have a framework contractor with a local laboratory. They do the sampling for us and analyze the samples.	Yes, we work with the Health Inspectorate, which conducts seasonal water quality testing at the bathing site on Lake Obłęże. The Health Inspectorate uses standard laboratory methods in accordance with bathing regulations – including the determination of pH, E. coli, temperature, and transparency. However, we do not have access to more advanced analyses (e.g., phosphates, nitrates) conducted on other water types such as stormwater or ditch water.	No information on the matter
Do you know of any automatic sensors that can measure those values?	Devices from Luode Consulting Company (procured through a tendering process) are high-quality automatic sensors that measure parameters such as turbidity, conductivity, temperature, and pH. Oil can sometimes be measured, but we have had problems with oil-related substances—perhaps hydrocarbons.	No, currently we do not have such knowledge or experience in using automatic water quality or level sensors. The municipality does not use such technologies, although we recognize their potential usefulness, particularly in the context of rapid response to extreme events and infrastructure investment planning.	No information on the matter

Can you list your suppliers of sensors and equipment for stormwater monitoring if you have any?	Luode Consulting Company provides turnkey solutions and offers excellent service, typically responding within 24 hours if any issues arise. The iProtoxi offers low-cost sensors (around 200 €/sensor), but they are not suitable for water environments—they broke quickly and are generally of low quality. We do not recommend them.	We are not currently using any sensors or monitoring equipment for stormwater, and therefore we do not cooperate with any suppliers of such devices. Any decisions in this regard will be made in the future depending on available funding and needs.	No information on the matter
What are your expectations or requirements for data resolution, frequency, or format?	Measurements are taken every 10 or 15 minutes. The data is then sent to the device's own data service, where it can be accessed by users with an account. The collected data is also being transferred to the City's IoT platform, via API (currently under development). The City plans to further develop the infrastructure to enable comprehensive data review and integration.	Our expectations are: • Measurement frequency – preferably in real time or with readings every 15–60 minutes for automatic sensors, • Data resolution – detailed enough to react to rapid changes (e.g., sudden rise in water level after a storm), • Data format – exportable to .xls, .csv, or GIS systems – comprehensible to municipal staff and emergency services (Fire Department), • Remote access – we would welcome the ability to view data online (e.g., via an app or website), or through a system based on the SCADA platform, allowing real-time observation of various parameters.	Measurements are performed using methods that ensure that the data obtained are reliable, representative and comparable. Ensure that the detection limit of the analytical method used in testing is equal to or less than the target value, limit value, of the parameter being analyzed as specified in regulatory enactments. Frequency that provides representative data that objectively characterizes the situation
Are there measurable thresholds or limits (e.g. regulatory, internal guidance) that are relevant for interpreting those parameters?	Not really. We have very few official guidelines or threshold values. There are some guidelines related to construction sites—mainly for side runoff. For water coming from those sites, there are threshold values for parameters like temperature, pH, suspended solids, and possibly oil. One of my colleagues is involved in a working group that is discussing threshold values in Sweden. They often need to refer to and use those Swedish values. I believe they have two different levels of thresholds. Those values can be problematic—for example, high phosphorus level is not usable for us.	Yes: • For bathing sites, standards are defined in national and EU regulations (e.g., E. coli, enterococci) – tests are conducted by the Health Inspectorate, • For nitrates and phosphates, we do not have local thresholds, but reference values from the Water Framework Directive and environmental standards (e.g., for eutrophication) are important, • For water levels in ditches and reservoirs – we do not have formal thresholds, but we assess each situation based on impacts (e.g., property flooding, lack of drainage), • We do not have internal guidelines – but we would follow the recommendations of environmental experts or Polish Waters.	Latvia has a regulatory framework that determines quality standards for surface and ground water - Cabinet of Ministers Regulation No. 118 of March 12, 2002 "Regulations on the Quality of Surface and Underground Waters"
What else should be considered when planning stormwater monitoring? / Lessons learnt/best practices?	Instead of purchasing sensors, it is better to use a turnkey service. Most municipalities lack the expertise required to maintain and calibrate the sensors properly. Additionally, some sensors tend to get dirty easily, which affects data quality and reliability.	From our perspective, it is worth: • Identifying risk areas (so-called hotspots) – places where flooding or runoff from fields occurs regularly, • Linking monitoring with investment planning – e.g., where stormwater drainage or retention reservoirs are needed, • Integrating data with the work of emergency services – fire departments, crisis management, • Seeking funding – e.g., from EU sources for climate adaptation, retention, environmental monitoring, • Involving residents – e.g., through apps for reporting floods or local observations.	Currently, the Augšdaugava municipality has not accumulated significant practical experience in rainwater monitoring. However, taking into account the specifics of the territory (for example, the presence of extensive natural water bodies, the risk of flooding in spring and during intense rainfall), this issue is more relevant. We believe that it would be desirable to focus on territories with a higher risk of flooding, cooperation with experts, universities is necessary, and the adoption of best practices from regions that already carry out this type of monitoring should be supported.

What data do you have? (e.g. data sources from cameras, satellites?)	Our current data sources mainly include monitoring data and laboratory analyses. In addition, we have a laser scanning program that provides highly accurate data—particularly useful for stormwater planning. For example, it captures 60 measurement points per square meter, offering a very high level of precision.		Publicly available data for everyone: for example, https://videscentrs.lvgmc.lv/
How is the data shared now?	We mainly share reports. When we take samples from streams and lakes, the Environmental Protection Unit is responsible for monitoring the lakes, for example. The laboratory analyzes the samples, and the results are compiled into a report that is then published on our website. As for online data, it's often too technical and specific for the general public to interpret, so we don't typically share raw data directly.		The Latvian Centre for Environment, Geology and Meteorology is an institution that ensures the collection, storage and provision of environmental information to the public and state and local government institutions in Latvia, including environmental monitoring, as well as participating in the implementation of state policy in the fields of geology, meteorology, climatology, hydrology, water and air quality, the impact of transboundary air pollution, and radioactive and hazardous waste management.
What data do you plan to collect and share in the project? Any challenges you foresee when sharing the data in our project?	Online data is shared internally for planning purposes, but not made publicly available—and we currently have no plans to do so. If we do develop our data infrastructure further, the level of openness will depend on our objectives, the nature of cooperation, and shared interests. It's not that the data is secret, but rather that its use requires an understanding of the context and purpose behind it. We do share data with our planning consultants to support proper planning, but not with external parties. However, students working on master's theses related to our environmental data are allowed to analyze it and draw conclusions. That kind of academic work is valuable, and the		Current information in flood emergency situations - urgent actions to avoid damage to property, the environment, health. Flooded areas are marked in the spatial plan, which provides information to the public about potential risk areas. Results of the monitoring, learning on experiences of other regions are examples of data planned to be collected and shared.
How will you technically share the data. For example, is there some kind of API's that shares the data? Or something else? (Some architecture)	We use an API to transfer the data to the City's IoT platform (IOP). Additionally, we can provide access to data service, for example, our planner.		We cannot provide the answer at this time.
Is there any legal framework that allows you to share the data? What rules and laws apply to data sharing.	We have a contract that ensures we retain ownership of the data, and we can maintain access to both the data service and the City's IoT platform whenever we consider it necessary. There may be specific rules or conditions related to this, but I'm not fully familiar with all the details. When we grant access to planners, for example, it's typically done under a non-disclosure agreement (NDA)		We cannot provide the answer at this time.
Have you or someone you know experienced flooding in this city? What happened?	Urban area, water entering the yard/basement/streets		

What's the biggest challenge you've faced during floods? (e.g., transport, power, safety)	Not big challenge, local events		
Where do you think flooding is worst in our area? Why?	In urban areas, we experience some local flooding, but it usually recedes on its own. We are quite aware of the specific spots that are prone to flooding, based on both modeling and practical experience. Some improvements are already planned, especially for problematic areas in the city center. The issue there is that the sewer system is undersized—it wasn't designed to handle today's intense rain events.		
What do you think are the main causes of flooding here? (e.g., blocked drains, heavy rain, river overflow)	The sewage system wasn't designed to handle such intense rainfall. In some areas, especially older ones, the pipes are small and outdated. The situation also depends on the duration of the rain event and the characteristics of the catchment area, so there's some variation. However, in general, it's most difficult to improve the situation in older areas because of the aging		
Are there early warning systems in place? How do you currently receive flood alerts?	We are making progress, and the flooding or warning system will eventually be integrated into the City's IoT platform, which is currently under development. The Finnish Meteorological Institute (FMI) provides weather forecast warnings—such as alerts for expected heavy rainfall—but those are general forecasts not on a local level. In terms of local monitoring, we have one weather station in the city center that tracks precipitation. However, flooding in our area usually subsides quite quickly. That's why, in our case, a real-time alarm system is not considered critical.		
Which streets/areas flood first or worst? Why? (e.g., poor drainage, construction)	The issue lies mainly in old areas with aging infrastructure—specifically the drainage system. These systems were not designed to handle the intensity of modern rainfall events.		
Are there recurring issues during floods? (e.g., sewage backup, power cuts, stranded residents)	Not relevant		
What kinds of volunteer programs or training would help citizens feel more prepared and empowered to help during floods?	Maybe in the fugure		
What communication channels (social media, community meetings, SMS alerts, etc) would be best reach a wide range of citizens during a flood emergency?	We aim to use existing information channels, such as the city app, to share updates and communicate with residents.		

What barriers do you think prevent citizens from participating in flood response or pollution prevention efforts and how can we address them?	This is also quite tricky because flooding is often very local. We're exploring some nature-based solutions, such as submerged dams or retention pipes, which help hold water in specific areas. However, these systems can sometimes get clogged by trash or debris like wood. We're considering placing signs at certain critical locations to encourage people to report if they see anything blocking the system—such as litter or other obstructions. In the stormwater team, we mainly receive feedback from citizens via email. Our website provides instructions for submitting feedback, and people often send us emails with descriptions and photos showing the specific location of the issue."		For some in society, flood and environmental issues seem to be solely the responsibility of the "state" or "municipality", therefore, public participation should be promoted by educating about the common good and personal benefits of active involvement (e.g., drainage systems, cleaning culverts on one's property). It must also be acknowledged that not all residents have access to the means or technical capabilities to take preventive measures (e.g., creating drainage, cleaning ditches, etc.).
How can we make flood preparedness activities more accessible?	Communication is always important.		To make flood preparedness activities more accessible to the wider public, it is necessary to ensure the availability of information, think about the way of presentation - the use of visual materials (infographics, short videos) with explanations would be desirable. It is necessary to build cooperation with local communities and NGOs, which can disseminate information further.
What infrastructure (e.g., drains, pumps, green spaces) is missing or failing in your neighborhood?	The flood routes are not fully connected throughout the drainage network. In some areas, there are interruptions or bottlenecks where the flow does not continue properly, which can lead to localized flooding.		
What info would you need in a flood alert? (e.g., water depth, safe routes, shelter locations)	Perhaps safe roads.		
How could technology (apps, sensors) help our community prepare? What kind of features do you need for such apps or sensors?	This is like in the future. Maybe with this IOP somehow to at least give information to people.		
What policy changes would you suggest to local government? (e.g., zoning laws, drainage upgrades)	I think the situation in Tampere is quite good. We are strongly committed to improving it further, particularly through the implementation of nature-based solutions. We have a dedicated program in place, and our work is well supported by the city strategy—even at the policy level.		
What would motivate you to join flood-prevention efforts? (e.g., rewards, community pride)	It's important to provide more information to citizens, for example, emphasizing that they are responsible for maintaining their own ditches and private drainage pipes. These are not part of the City's maintenance responsibilities, so property owners need to ensure they remain clear and functional.		
Who else needs to be involved? (e.g., schools, businesses, religious groups)	they have these resident residence organization. they are active, they always send this little magazine. For you, every twice a year or something and they inform about the events that are happen.		

What support do you need from authorities/NGOs to make this happen?	We have initiatives like participatory budgeting programs in different residential areas. In these programs, the City allocates €30,000 to a specific neighborhood, and the residents themselves can decide how to use the funds. They can vote or collectively agree on the priorities. This approach increases engagement and gives people a stronger sense of ownership in their community.		
What apps do you use for weather alerts or emergencies? What do you like/dislike about them?	We use only FMI app on our web page.		In flood management cases, the website https://videscentrs.lvgmc.lv/ is used, which is maintained by the Latvian Environment, Geology and Meteorology Centre, which carries out continuous monitoring of actual meteorological and hydrological conditions, as well as follows these changes, prepares weather forecasts both for the very short term – the next few hours, and for longer terms – up to six weeks ahead and also in a seasonal perspective. Long-term monitoring data is used for analyses of climate and historical hydrological conditions, which also forms the basis for assessing changes in future climate and hydrological conditions.
When flooding happens, what's the first thing you do to check for updates or report issues?	We always review our monitoring data, especially during rainfall events, e.g., recipitation data. The local newspaper is also active in reporting on flooding events, which helps ensure the public receives the latest updated information.		
What information do you wish you had during floods? (e.g., real-time water levels, safe routes, emergency contacts)	Safe routes and the 112 emergency system are important, but this is probably an area we need to pay more attention to in the future. We'll see how the situation develops—especially in terms of how much more water we can expect with changing weather patterns.		
How would you like to report floods in the app? Through text, location sharing, photos, or some other ways?	Location sharing if there is an app		
Would you like to contribute data? Such as uploading flood photos, marking unsafe areas.	Good idea.		
Who should verify reports? Such as other users, or government?	If for city, this will, of course, mean more worky. Often, even when water levels rise during a flood, the situation can resolve itself—the water may already be gone by the time someone checks it. These events frequently happen at night or over the weekend, so by Monday, everything might appear calm. We do have an emergency center that is responsible for coordinating all emergency services. There are commonly agreed guidelines in place that define responsibilities—such as who responds and when. Typically, first responders include emergency services, fire and rescue teams.		

What successful example have you seen locally or elsewhere of citizen engagement during flood events that we could learn from?	Not really. Flooding usually only lasts for a few hours and then disappears. We are aware of the spots where flooding tends to occur, and we do our best to address these issues—whether it's fixing pipes or improving connections to help the water drain away. It's our responsibility to fix the underlying problems, plan the necessary improvements, and make long-term solutions. However, if help is needed during an actual flooding event, that falls under the responsibility of emergency services. Often, the issue is not just one pipe—it's that a large catchment area is directing water to a single point. So simply adding one new pipe is not enough. You have to look at the bigger picture and consider the entire drainage system.		Response and cooperation of the municipality and residents during the spring floods of 2023 in the city of Jēkabpils, when there was a significant threat of the protective dam collapsing

Questions	Örebro Municipality
Does your organization have challenges with stormwater? (e.g. quality, flooding)	Yes – according to environmental quality standards our recipient needs to be improved, and stormwater quality is one of issues we need to work with. We haven't had so many big floodings, but we had one incident during august 2023 that led to many basements flooding.
What information do you currently collect/monitor about stormwater (e.g. flow, turbidity, contaminants)?	We don't have any continuous monitoring – we instead have some targeted surveys of often flow but sometimes pollutants.
For what purpose do you need information on stormwater quality (/quantity) (e.g. infrastructure planning, pollution control, public health, regulatory compliance)?	It's when our environmental office asks, for pollution control or for new infrastructure planning (but then they often use models for pollutants calculations).
What additional information about stormwater would you find useful for your work or responsibilities?	Continuous flow measurements and more rain gauge.
Which specific parameters or indicators (e.g. pH, nitrogen, E. coli, microplastics, conductivity) do you think are most important to monitor in your area?	Depends on the catchment area and what problems there is – it's hard to say specific parameters that can apply on every catchment.
Can you list your suppliers of sensors and equipment for stormwater monitoring if you have any?	We don't have any.

What are your expectations or requirements for data resolution, frequency, or format?	Can't specify because it depends on what we want to know – its different every time.
Are there measurable thresholds or limits (e.g. regulatory, internal guidance) that are relevant for interpreting those parameters?	No, our environmental office are in the long run not planning to apply to thresholds or limits, but more with preventive measures regarding pollutants.
What else should be considered when planning stormwater monitoring? / Lessons learnt/best practices?	Stormwater can vary from catchment area to catchment area and from rain event to rain event, different seasons (snow vs rain) which make it difficult to draw general conclusions.
What data do you have? (e.g. data sources from cameras, satellites?)	Today we mostly have continuous flow measurement of smaller rivers and creeks in Örebro, as well as continuous bacteria and pollutant concentrations of common pollutants in our rivers and creeks, receiving stormwater from targeted catchment areas.
What data or information do you currently share with the public?	Nothing concerning stormwater.
What data or information should be shared with the public? What might be interesting?	I think rain monitoring is the most interesting.
How do you currently reach out to interested citizens?	The municipalities website.

Questions on V-overflow

	LAPP Water Company	Augšdaugava municipality	Xepto AS
Do you have overflows in your pipeline network today?	There are no overflows in our sewer networks. It was also modelled in the network model, and it doesn't seem that the overflows would happen either, we have such a loose network.	The average population density in the territory of the Augšdaugava municipality is only 10 inhabitants per square kilometre. The municipality includes two small towns – Ilūkste with 2072 inhabitants and Subate with 537 inhabitants, but the total population is 23840. Consequently, rural populated areas predominate. In more densely populated areas, especially during heavy rainfall, local problems arise, which are facilitated by outdated rainwater drainage systems and insufficient pipeline capacity. Such situations are more typical for settlements with older engineering infrastructure, where sufficiently efficient water drainage is not ensured.	Yes
How do you measure overflows today. Number of times with overflow, or number of times and quantity?	Overflow times are monitored. The times can be seen from the remote monitoring by pumping station, you can see e.g. the latest overflow time and get from the report how long the overflow has lasted and how much water would have been lost, but it is indeed calculated.	The municipality has not yet purposefully listed or analyzed overflows in the stormwater sewege network.	Gjøvik municipality measures the number of events, duration of overflows, and volume in cubic meters.

What are your expectations or requirements for data resolution, frequency, or format?	Remote monitoring of pumping stations updates the level data of the pumping stations once a minute.	No expectations	Calculations are made using known formulas where contact-free sensors and radar are used. During overflows, measurements are taken at a frequency of every 60 seconds. The supplier has equipment for calculating overflows for different types of overflows: V-overflows, edge overflows, and manholes with pipe overflows.
Do you have routines for following up on these measurements?	Well, in a way, there is continuous monitoring. It is constantly monitored that the overflow of the pumping stations is being monitored through the high beam drawdown program. Or in pumping stations, the water level is constantly monitored, but when we don't have overflows, we don't run any reports on them or do any separate monitoring afterwards	No data available	
How do you follow up on overflows? Do you report this to the authorities or is it just for internal use?	These results of the official monitoring are reported to the ELY and the Lappeenranta Region Environmental Department, which act as official supervisors.	Information on overflows from domestic wastewater sewer networks must be reported to authorities. Overflows of storm sewer networks are monitored internally.	
How do you maintain the overflows?	But yes, we always go with a suction truck if there is an overflow situation to try to minimize the amount of wastewater that ends up in nature. If there is a smaller pumping station like this, then we start emptying with a suction truck if there is a pumping station of such size that it can be controlled with a suction truck in the possible overflow situation.	The operations are carried out by communal municipal services.	

Are there any public requirements from the government that there should be measurements on the overflows you have in your stormwater and sewage facilities?		The regulatory framework sets out requirements for the installation of emergency discharges and overflow points for domestic wastewater, and their operation is regulated by the conditions of permits issued by the State Environmental Service, so that the environmental quality objectives of surface waters are met.	
Can you list your suppliers of sensors and equipment for V-overflow if you have any?		No data	Xepto As

Interviews with Finnish National Authorities

	ELY-keskus
Do you have an estimate of the extent of damage and costs?	This is probably more going to the municipalities' plot, at least for me it is completely guessing. I don't dare to start guessing here. I think that at least not all the minor damage caused by stormwater may even be known to us.
What are the requirements for handling stormwater and are any changes expected in the near future?	The treatment requirements are such a thing that it is more and more on the agenda, but we don't have any definite information, but one could assume that this will be discussed in the near future, and since these storm water must not even be led to any wastewater treatment plant, but one could assume that those requirements will not decrease in the near future. My gut feeling is that there aren't many of them in the legislation, other than general clauses, prohibitions on pollution and the like. But I don't remember that there are any quality requirements for stormwater. We guess, or assume, that there will be new regulations, but that's just this kind of speculation. You don't know what kind of ones are coming.From there, through the VPD, I think there are those related to nutrients and such, but then there are probably no limit values for solids.
How do you assess the current stormwater management in municipalities?	Well, I'd guess it varies. That mixed sewerage has probably not yet been completely eliminated in any municipality. For example, stormwater management is visible in newer projects. Let's use these kinds of slowdown structures, so in that sense we do try to do quantitative control. Different types of arrest solutions.
What requirements are currently imposed on municipalities regarding stormwater in new development projects?	This is a good question, I'm not sure if it has been reformed in the Land Use and Building Act. Or the law on the use of areas. The new legislation, what kind of requirements are there? At least in the old legislation, it was stated that they should primarily be processed on their own plot and secondarily led into the sewer.At this point, we are more responsible for the municipalities than the ELY Centre.

How is it ensured that municipalities actually implement the necessary measures?	Well, probably one of the most important is the plan statements, that if we think specifically from our point of view, how we can promote in the plans that the municipalities prepare, these things would have been taken into account.But of course, it's a good question to ask whether we can demand anything, I can't say anything about that. Municipalities must act in accordance with the provisions and legislation. Of course, the state of the waters must not be deteriorated. Yes, and it is then easily ex-post control measures, to notice that there are impacts on waterways from here, so at that point our unit will of course wake up, but it may be that we are in the implementation phase, that we can be aware of how they are done in practice, that we trust that they will be done according to the regulations.
Is the current legislation and regulations sufficient to handle stormwater challenges?	Well, as practice has shown, when there have been these stormwater floods in cities, the sewers have clearly been undersized in this ever-changing situation, and at least in some places, these stormwater floods have become quite significant, so of course the legislation and regulations guide the stormwater construction. Then they are tightened. Watching from the sidelines, it seems that the regulations or implementation have not been sufficient. And of course, then the harmful substances and nutrients and solids of stormwater. From the point of view of the waterway, the fewer there are, the better.
How do state actors collaborate with municipalities and private actors to solve stormwater problems?	Well, our agency as a state authority, that we have this kind of guiding and advisory role. In different contexts indeed, and then the plan statements. Well, of course, there are these disputes under the Water Act, that we have parallel competence with the municipality's environmental protection, and then the drainage supply customer is then the ELY Centre's business.
How are considerations for nature-based solutions (e.g., green roofs, rain gardens) balanced with traditional infrastructure?	It is really challenging that if there is a dense surface throughout and then a very densely built one, and then stormwater is directed from there to a sewer that is dimensioned in the old days and is not enough for today's heavy rains, then it is a challenge to find out where to fit those natural solutions and retention structures in general.
How are you preparing for increased rainfall and extreme weather in light of climate change?	In our area, there are these huge solar power plant areas being planned, and there will be stormwater, and other such larger projects where there are clear stormwater effects, so we have taken into account that extreme weather phenomena have increased, that when water comes, a month's amount of rain will collapse at once, and that must then be taken into account in these retention structures. Actually, climate change policy is now included in all activities and modelling as well. Yes, on those flood maps you can find the climate change scenarios for the sea coast, for the entire Finnish coast. Climate change scenarios modelled with different emission factors.

How do you assess the risk of flooding and stormwater in urban areas in future climate scenarios?	Well, it's quite clear that it will grow. There is a growing risk, but how much, it remains to be seen, but at least it will not ease.Then, at the other extreme, there is also the drought.We support all appropriate research, but it would be interesting to find out specifically in relation to these nature-based solutions how they will last if there are these extreme droughts, whether they will work then, and if there is an extreme drought situation and then there is a huge heavy rain, will they work? And if all the vegetation is dead from those nature-based solutions.Well, of course, the water protection association mainly works with the funding of municipalities and other members, so they can then apply for funds from different financial instruments, and I think that the ministers are quite well aware of these different EU financial instruments, but then. Also the regional councils distribute EU money, how well the ministers and individual officials necessarily know about these. Yes, and they do indeed have a wide range of strategies, and then there is the provincial planning authority as well, so that a regional authority is essential in this area as well.The Centre for Economic Development, Transport and the Environment does not have a position on the introduction of the stormwater fee.Of course, now there will be more costs for municipalities if the requirements become stricter, the money will have to come from somewhere, whether it is taxation or the stormwater fee, so it is clear that the money will have to be ripped from somewhere.
How can citizens and private actors contribute more actively to stormwater management?	Well, I am reminded of stormwater or flood risks, these preliminary assessments that by participating in them. There is a hearing that the ELY will take care of it for coastal areas and then the municipalities will take care of the stormwater flood risk assessment specifically for urban areas. Let's just say that there is quite a bit of feedback on these in general. Although they are actively communicated.
How do you work with interdisciplinary cooperation between planning, environment, and the water sector?	Here, too, we have a guiding expert role, and when we are asked to participate in a project, we naturally try to be involved then. A separate water supply unit, which operates in South Savo, so it's a bit of a question mark what interface they have with stormwater.

	Finnish Environmental Institute
How are you preparing for increased rainfall and extreme weather in light of climate change?	The Flood Centre is a joint service of the Finnish Environment Institute and the Finnish Meteorological Institute, which predicts and warns of floods and maintains a picture of the water situation. The tasks have been divided so that seawater floods and heavy rain floods are the responsibility of the Finnish Meteorological Institute, and water floods are the responsibility of the Environment Institute. In terms of drought, both are included. Preparation: we have already had to change our own activities, before there was snow and frost in the winter, this is no longer the case, even in winter there are floods every now and then. Snowy winters are becoming less frequent. It seems that we have to think about, for example, the standby of the flood duty officer, in other words, the adaptation of practical operations. The climate has already changed from before. In any other way, the flood centre has not yet had the need to react. Of course, we make a lot of forecasts and calculations about what increased precipitation means in terms of water levels and flows, how to affect the regulation practices of water bodies. Stormwater floods: we calculate the amount of precipitation in the area, which has an impact on the water levels and discharges of water bodies, among other things. When talking about extreme weather phenomena, stormwater floods have been identified, that we need to pay more attention to competence, works in the borderland of SYKE and Finnish Meteorological Institute, for forecasting, stormwater floods occur in cities when it rains a lot or snow suddenly melts quickly, rain causes greater damage, more interested in it and forecasting ability, stormwater floods are extremely difficult. Nowcasting: Near-moment forecasting, piloted in Helsinki and Turku, launches a surface runoff model that calculates how much stormwater and where, which places will be submerged if this happens. The idea is to send a wake-up call to the rescue department, who get a little head start on the situation, get to the scene in advance, for example. to close the underpass. It was noticed that forecasting is difficult, but in the future, the focus areas of the development of the Flood Centre's operations.

	Ministry of the Environment
How do you assess the current stormwater management in municipalities?	Municipalities are key actors in this, for example, in organising the monitoring of land use and construction, as well as public areas, but also the environment and water characteristics. It is municipality-specific how extensive cooperation and responsibilities are divided with the organisation of water services. There are differences in the water and sewerage systems of municipalities/cities of different ages built in different eras (e.g. mixed sewerage or separate wastewater and rainwater sewers). Correspondingly, in areas outside the core urban area, stormwater is directed to natural runoff routes and open ditches. Municipalities promote stormwater treatment in their activities. For example, by using structures that slow down water absorption or water-permeable materials. Delayed reservoirs or reservoirs can also be built. At the same time, these measures are related to the utilisation of the properties of different plant covers as part of the planning and use of the immediate environment of the residential area, for example.
How can municipalities get support to implement good stormwater measures?	There is a Stormwater Guide for the implementation of stormwater measures. YM has been involved. An update of the guide is being planned (Association of Finnish Local and Regional Authorities). The guidance material is a significant operationalisation of the implementation of the law. The guide has been widely used and the update provides an opportunity to increase the information gained in practice, e.g. on good practices and planning principles. -https://www.kuntaliitto.fi/julkaisut/2012/1481-hulevesiopas -Supplement, e.g. https://www.kuntaliitto.fi/julkaisut/2017/1829-hulevesioppaan-paivitetyt-luvut-lainsaadannon-muutosten-osalta -Stormwater planning is part of land use planning and urban planning. The stormwater element is also part of the planning of the immediate environment of residential and urban areas. In addition, cooperation between different actors is also a key element of support.
Are economic instruments being considered to stimulate more sustainable stormwater management?	Issues related to the use and allocation of various financial instruments and the allocation of the funds received are largely the comprehensive organisation of the activities of municipalities. Key legislation related to land use and construction as well as community development and planning strongly includes the dimensions of climate change and adaptation. Municipalities and regional actors more broadly can make use of the European Union's various financial instruments according to their allocation. The European-level steering related to urban wastewater may also produce measures linked to stormwater.No discussion of special support from the state. [The state has granted so-called infrastructure grants (e.g. 2020–2023) for the construction of municipal engineering in residential areas. It has not been possible to apply for the grant in 2024. The aim of the municipal engineering grant was to start and bring forward the construction of new housing areas in growth centre areas. The grant was awarded to municipalities that have signed a letter of intent with the state on land use, housing and transport (MAL agreement)].
What is your view on introducing stormwater fees as an incentive for local measures?	Even today, municipalities charge various fees related to water supply and its organisation, as well as stormwater, for the implementation of maintenance work, for example. Procedural solutions vary and are determined by the prevailing situation at the time.
What data do you have? (e.g. data sources from cameras, satellites?)	At the moment, there are also several national information system projects underway. Information on buildings and land use is placed in the Built Environment Information System (Ryhti - Built Environment Information System, Finnish Environment Institute). In terms of land use, the system includes detailed material on land use, among other things. In addition to open services, the system includes services that are separately restricted to the authorities. A permanent building identifier (VTJ_PRT) is a key identifier that identifies buildings. The Flood Information Centre maintains flood data maps. (e.g. flood risk maps). In the acquisition of information and the development of reporting, the new national datasets that are formed can also be utilised in several different use cases.

Interviews with Norwegian organization and companies

	Wioniq-Piplife	Environmental health protection IKS	Xepto AS
Does your organization have challenges with stormwater? (e.g. quality, flooding)	Yes, I would say it is a National problem, or Global problem if you want to put it that way.	Bathwater pollution. We monitor water quality at bathing areas and surface water can affect bathing water quality	
What information do you currently collect/monitor about stormwater (e.g. flow, turbidity, contaminants)?	We collect information for a number of customers across large parts of Norway. Water level and water flow measurements for municipalities, SVV, BaneNor and Statkraft, often in combination with camera images. In addition, we have a number of water parameter measurements such as pH, Conductivity, Salinity, TDS, temperature and turbidity.	Indirectly by bathing water samples – e.coli and intestinal enterococci. Samples for the level of the Hunnselva. Also looking at water levels and possible local conditions when taking bathing water samples. We may also receive inquiries from the public if there is suspicion of poor water quality/pollution.	
For what purpose do you need information on stormwater quality (/quantity) (e.g. infrastructure planning, pollution control, public health, regulatory compliance)?	We only assist customers in obtaining information about stormwater, as well as assisting with interpretation and improving solutions to get even better and more relevant information	Bathing water quality (public health). It is useful to know where any drains/outlets go so that we can pay attention to bathing areas – also if we are going to give input/new recreational areas/bathing areas are going to be planned	
What additional information about stormwater would you find useful for your work or responsibilities?	Prediction of the amount of water ahead of a large water flow/flood is useful information, as well as how much snow that turns into water remains in the mountains and when it will come down as water. One will then be able to issue advance warnings that can help reduce the extent of damage with large water flows.	Where stormwater flows into Mjøsa and Hunnselva for bathing and recreation. We also get questions from the public. Also regarding local streams and drains	It is important to have information about surface water pathways to avoid water ingress into buildings. Correct capacity in the pipe network is crucial, especially during heavy rainfall.
What measurable values do you see that reveal the information you want to know?	For stormwater, the amount of water per unit of time is an important factor, and when the water will pass through different areas on its way to the sea. It can also be interesting to measure some water parameters to look at pollution in the water.		Deviation in capacity, calculated versus actual.

Which specific parameters or indicators (e.g. pH, nitrogen, E. coli, microplastics, conductivity) do you think are most important to monitor in your area?	I would say that depends on where it is to be measured, you can do an experiment with a few more parameters on a more advanced "test unit", and where you see that you have low normal values, you can choose from the results what you want to monitor further of the measurement parameters, and insert a logger with fewer sensors specific to the location.	E.coli, more specifically bacteria/viruses (most are captured by e.coli measurements) cf. Outdoor swimming pools – the municipality's follow-up and control of bathing water quality - Directorate of Health Microplastics are of interest, as we know little about how they affect.	
Are you aware of any laboratory analytical methods that can measure those parameters/indicators?	Sensors and "Micro laboratories" (measuring stations) are available for the most part.	Yes, Mjøslab IKS and the methods they use.	
Do you know of any automatic sensors that can measure those values?	So far, there are no sensors that we have not been able to obtain, and I believe we will be able to solve all sensor needs that may arise.	No	
Can you list your suppliers of sensors and equipment for stormwater monitoring if you have any?	VEGA, Holykell, Sensomatic, Iprotoxi, Wioniq, AquaLabo, In-Situ, RIKA, Sick, Telemacanique, Maxbotic etc.	I don't know of any, apart from Mjøslab for water samples.	
What are your expectations or requirements for data resolution, frequency, or format?	We can provide good data quality, high resolution, "desired sampling frequency" in several formats.	An annual overview of current parameters	An optimal resolution of data compared to the resource usage of the instrument.
Are there measurable thresholds or limits (e.g. regulatory, internal guidance) that are relevant for interpreting those parameters?	We usually set threshold values for all water level measurements with normal status, alarm and high alarm on the water level, with subsequent alarms by email or SMS. Then preferably also with a picture when the threshold is violated.	Yes, bathing water standards Outdoor swimming pools – the municipality's follow-up and control of bathing water quality - Directorate of Health. https://www.helsedirektoratet.no/forebygging-diagnose-og-behandling/forebygging-og-levevaner/miljo-og-helse/friluftsbad	

What else should be considered when planning stormwater monitoring? / Lessons learnt/best practices?	You should have a fixed reference point to the 0 point, as sediments can change the "bottom" and the original 0 point. You should not use diving sensors where there is a possibility of a lot of sediments. Today we mostly only use radar sensors for water level measurements, but there are some exceptions. We now have 5 years of experience with this and are happy to share our knowledge, the solution is adapted to each individual location after assessing the space and needs. Have gained and shared experiences and knowledge with Hydrologists from NTNU, NVE and Statkraft, BaneNor, SVV and various municipalities around.	Use of stormwater for facilities/fountains or other places where the public can use/come into contact with the water. Does this pose any risk of people being exposed to an impact, or possibly the risk of spreading legionella or other bacteria?	
What data do you have? (e.g. data sources from cameras, satellites?)	We can send on Lora, NB-IoT, Bluetooth, 2G, 3G, 4G, 5G and Iridium (satellite).	Bathing water samples in the form of water samples	
How is the data shared now?	Our "front end" access or in setting up the API, is sent via email or SMS.	Results of bathing water tests on our website (mrhv.no)	
What data do you plan to collect and share in the project? Any challenges you foresee when sharing the data in our project?	We will collect the data you want or we agree on, we can also make suggestions if there are things we think could be useful that you have not included. We again see challenges with participating in the project, we look forward to being a part of this and collaborating with the parties involved.	Bathing water samples. Feel free to share with the project	
How will you technically share the data. For example, is there some kind of API's that shares the data? Or something else? (Some architecture)	We set up an API or rest API depending on what you want and who will see the information. Some can also be viewed in the mobile App, depending on the type of loggers used. All measurement data can also be viewed in our "front end" if desired.	The Gjøvik municipality website «https://www.gjovik.kommune.no/tjenester/kultur-idrett-og-fritid/tur-og-fritid/sommer-og-hostaktiviteter/badeplasser/» is still being updated, it seems?	

Is there any legal framework that allows you to share the data? What rules and laws apply to data sharing.	The data is owned by the paying customer, we cannot share it without the customer's consent. We have experience with data sharing between several of our customers where it serves the "common/public" interest.	We "own" the test results, but they are public property and can be shared	
What data or information do you currently share with the public?	We currently share many different measurements depending on the customer, but typically water level, images, temperature, water parameters etc. We are also the hub that shares information between SVV, Entreprenører and BaneNor as they all have installations and infrastructure in the same area. Data sharing is important to get ahead of, for example, floods in Gudbrandsdalen where the E6 has to be closed, something we have been a part of several times and our installations are used on a daily basis to make assessments on this		
What data or information should be shared with the public? What might be interesting?	Where possible, data of public interest should be shared, when it can increase safety for those traveling along roads and railways, or living in the surrounding area. From our installations, data is mainly shared between operating engineers at state, county and municipal services. More like those who have swimming pool temperatures and water level measurements of public interest posted publicly on their municipal pages.		
How do you currently reach out to interested citizens?	The question is what it concerns, and what we should share. In some municipalities we have set up an API for the municipality's website where measurement data such as bathing water temperature is shared, in other places also water level in rivers for rafting. This is an example.	When they contact us, via websites/social media or media.	

Interview with Mjøsa Joint Fishing Association

Questions	Mjøsa Joint Fishing Association
Does your organization have challenges with stormwater? (e.g. quality, flooding)	We have observed challenges related to increased turbidity and nutrient loading in Lake Mjøsa. This has led to concerns about algal blooms and reduced oxygen levels, which could negatively impact fish populations and overall water health.
What information do you currently collect/monitor about stormwater (e.g. flow, turbidity, contaminants)?	We mainly focus on monitoring water color, turbidity, and the presence of algae on the surface. For other parameters, such as pH, conductivity, and contaminants such as heavy metals and microplastics, we rely on data from municipal sources. This information helps us assess the health of the lake and identify potential problems.
For what purpose do you need information on stormwater quality (/quantity) (e.g. infrastructure planning, pollution control, public health, regulatory compliance)?	The information is primarily used for pollution control and to ensure compliance with environmental regulations. It also guides our advocacy efforts for better environmental policies.
What additional information about stormwater would you find useful for your work or responsibilities?	Predictive models for quality and stormwater runoff would be very useful. In addition, detailed information on the sources of pollutants and their pathways into the lake would help target efforts to reduce the problems more effectively.
What measurable values do you see that reveal the information you want to know?	As mentioned, we focus on water color, turbidity, and surface algae. For other parameters, such as acidity and nutrients, we use municipal data. For example, information on nitrogen levels helps us select the best fishing spots. High levels can lead to algae blooms and reduce oxygen in the water, which affects fish.
What else should be considered when planning stormwater monitoring? / Lessons learnt/best practices?	Comprehensive and continuous monitoring sounds useful. Integrating data from multiple sources and ensuring collaboration between stakeholders are best practices that improve stormwater management.

Interviews from TransformAr

Questions	Lappeenranta City	Lappeenranta City	Greenreality
What information are you currently investigating about stormwater?	• Streets and surroundings are currently not followed by anything. • In the event of a problem and during construction, capacity is considered	• Requires reports from; infrastructure builders, industries that discharge water, complaints • Sampling is not included in the activities of the authorities • Participate in projects that investigate stormwater quality. • GreenReality has projects related to the state of Saimaa. Wetland sampling is also here.	• The main target is Pien-Saimaa, the problem is eutrophication • Amounts of nutrients (nitrogen and phosphorus) ((phosphorus most important in inland waters)), amounts of solids (sand, humus) • PH and electrical conductivity • Flow • Oxygen content is essential information for the water quality of the lake, measured at different depths • Contaminants not studied: petroleum compounds, heavy metals, microplastics (occasionally) • Wetland activity has been monitored 3 times a year (spring, summer and autumn), water samples in the laboratory • No automatic measurement • Suninenlahti automatic measuring equipment (ferry), measures the quality of lake water: temperature, oxygen, chlorophyll, no access to nutrients other than indirectly -> enter data into the server • Practically lab samples on schedule, no special monitoring during heavy rains • Bacteria monitored from wetlands (no relevant information)
For what use do you need information on the quality (/ quantity) of stormwater?	• Networks belong to the streets and the environment. • The possible existence of harmful substances is of interest. • Water status a concern.	• Environmental action interprets data and results -> issues statements, regulations and instructions based on them	• Understanding the state of Pien Saimaa
What information would you like to know about stormwater, or what do you see worth storing?	• Harmful substances • Rainwater volume to ensure sufficient network capacity • Flood problem areas are known.	• From the perspective of Pien Saimaa, phosphorus and nitrogen compounds and oil compounds • Matters affecting the Saimaa watershed, e.g. solids and metals • Nutrients, oil compounds are the most important. • It is probably not possible to measure solids with sensors. Maybe with a camera. • Sensory function of phosphorus and nitrogen compounds. • To what extent, for example, oil is transferred from the street area to stormwater and further to groundwater • Information on the functionality of different options as a function of time + in winter conditions • Information on the functionality of filtering solutions and the need for maintenance	• Oxygen content in wetland monitoring would be valuable. Warm, hot, no rain, small discharges -> basin deoxygenated, nutrients are released again and run into the lake. • Continuous monitoring • How wetlands work, whether they retain nutrients and solids

What identifiable or measurable values do you see revealing the information you want to know?	• Volume m3 / h etc. • On the edge of the hotspots, came from a land to the stormwater network, Kettukallionoja, studied: • Mustola, slag (Mustola, kuona?)	• Information is obtained through the measurement of electrical conductivity.	• See question above.
Are you aware of any laboratory analysis methods that can be used to measure those values?	No	• Analytical methods can be found for almost everything. Also accredited. • Saimaa Water and Environmental Research Ltd .: laboratory; oxygen, nitrogen, phosphorus compounds. Electrical conductivity.	• See first question. • It is a good idea to calibrate automatic monitoring from time to time with laboratory measurements. • The water sample going to the laboratory should be less than one day old.
Do you know any automatic sensors that can measure those values?	No	• No further information. • There are no sensors in the Lpr. • There are electrical conductivity sensors in the industry.	• Suninen Bay has an automatic (portable elsewhere) measuring platform; temperature, oxygen content (2-3 depths) and chlorophylls (phycocyanin (pigment) = cyanobacteria) • EHP Environment, as of 2010, feeds to the server, available as an exam or graph • Automatic sensors are used in peat production areas; flows, color, solids
Do you know the limit values or ranges for analyzing and understanding the different measurable values?	No	• Limit values are only for domestic water. Two steps; qualitative and aesthetic limit values related to use • There are ranges for natural waters that determine the chemical status of the water. Nutrient amounts (nitrogen and phosphorus). There are certain types of "thresholds" that determine whether a body of water is rugged (oligotrophic), more lush, or super-lush. • There are typical values for groundwater (phosphorus, nitrogen, sodium, chloride, oxygen). Used to compare groundwater to the general level. There is variation. Sliding things.	• There are no official limit values, the assessment is based on one's own knowledge • Incoming and outgoing concentration, compared. Concentrations (nutrients) even increase in some areas (eg in peatland) -> problem, wetland needs restoration • The load entering the lake is monitored, but not actually compared to the lake water quality requirements • Concentrations should be proportional to flow. That is, the country (and probably the volume more generally) is important information.
What else should be considered in the TransformAR project when planning stormwater analysis?	• Volumes • Problem areas • NBS solutions rather than building a new network • Treatment of the stormwater network as early as possible. As far away from Saimaa as possible.	• Functionality of different filtration materials in Finnish / northern / seasonal conditions. Power of different materials. • It would be desirable for easy solutions to be introduced for stormwater treatment before the waters are even discharged into the stormwater network.	• Sensor experiment for wood chip filter + biochar solution • Automatic data from Ruoholammi's experiment for us too

Others	• Overflow basins at the intersection of the old Vyborg road and Joutseno • In groundwater areas, ramps have bentonite mats to prevent runoff into groundwater in the event of an accident. In addition: NBS locations	• There is no information on how the filtering capacity of filtering solutions changes with age. That is, no information about service intervals. • Green Reality has made a report on the need for wetland maintenance measures. • Possible filtration methods that do not require vegetation: biochar, activated carbon	• If oxygen is depleted from the bottom, nutrients are released and algal blooms accelerate -> Internal load. • Satellite monitoring (EU project) to predict future cyanobacterial blooms • This project focuses on monitoring and understanding. Solutions to the problems now identified in the next project. • Annual maintenance of wetlands: o mainly mowing vegetation from the edges, clearing trees. o No filters enabled. o Shungite filter tested in Sammonlahti wetland (in cooperation with LUT, KK Haapaselkä) for 2 years, studied e.g. Nitrogen, heavy metals, oils o Mudballs tested in the Sammonlahti wetland: clay, microorganisms, the same as at the bottom of the lake in any case, decompose organic matter, were thrown to the bottom of the basin -> water clarified in two weeks, phosphorus decreased by 70%. Mudballs were left in the wetland, about 6 months of active operation. LUT / Satu-Pia. In a lush, mud-bottomed pond, not so much of an impact. From Japan originally? • Savings Bank Foundation funding: wood chip filter + biochar, target not yet known, not for stormwater crime but for the countryside (requires more space), possibility to monitor? • Ruoholammi (Ministry of the Environment funding, decisions coming at the end of April), water protection plan for the catchment area, construction of a site, automatic monitoring (Simo Sihvo), project for a couple of years • Blue-green algae: causes nutrients, but there are other factors. 2019 flower throughout the winter, biomass increased until February. Bacterial in structure. • Continuous monitoring is important, calibrated by water sampling

Questions	Lappeenranta City	LUT	Saimaa Water Protection Association, SVSY1
What information are you currently investigating about stormwater?	• Information on the amount of stormwater to be able to calculate the area requirements for delay zones / ditches • How stormwater is managed, what kind of area reservations are needed • In order to provide general regulations on the principles of stormwater treatment, what management solutions are used • Now gone on a case by case basis, could you type and classify where you can absorb and where you can't • The formulas do not go into the precision of defining technical solutions, although a formula regulation may force a certain technical solution, usually left at the planning permission and implementation planning stage • Stormwater as a whole: the effects of the solutions occur elsewhere, eg network capacity is exceeded downstream -> wider spatial data set prerequisite for wider assessment -> database: new formula produces so much more stormwater, program would show where capacity is exceeded • How to ensure groundwater quality in groundwater areas	• Flood management, risk management, availability of treatment, set of stormwater components, what components are included - no online analytics • It is a different matter what makes sense to measure in real time vs. Sampling eg meltwater, taking water samples and doing a more comprehensive analysis at once • Turbidity can be measured automatically; small particles makes turbidity, does not settle in the piping • Measuring platform: Chloride, temperature, oxygen, chlorophylls. Does not measure metal emissions; copper, zinc and nickel, perhaps aluminum, iron, manganese. Al and Fe precipitate phosphates. • No real-time measurements have been taken	• The association promotes water conservation, -10 people: in water conservation projects, a couple of three permanent and four temporary plus an office. Focus on projects. • Oy produces commercial services, about twenty people • Some analyzes are performed in-house, some are forwarded: eg PAHs • Focus on agriculture and forestry, through wetlands, wetland monitoring, mainly in agriculture and forestry, taking water samples from wetlands, lakes and ditches • Nutrients, phosphorus, nitrogen, soluble forms, pH, chemical oxygen demand • The amount of runoff from ditches, eg the water body load study from future ditches, the concentration of the load is calculated • A carbon project is underway • Wetland monitoring within the framework of projects, sampling 3 times a year, also during flood peaks
For what use do you need information on the quality (/ quantity) of stormwater?	• The quality of stormwater affects what needs to be done in the design area (qualitative measures to improve). Often when the water is delayed, the quality also improves • Groundwater is an important issue, most of the urban area is a Class 1E groundwater area -> What measures are needed, how the formula addresses in particular larger parking areas, quality improvement of stormwater, model cases Kaukaan Lehmus + Prisma. • Wide range of conditions and solutions, wide cost implications, to create model solutions for areas located in the groundwater area close to the groundwater intake, vs. sites located hydrogeologically farther from the water intake. Model solutions for how parking lot wastewater should be treated. • Qualitative groundwater management is one issue • Quantitative issues where there are no groundwater areas, nor land that can be absorbed, e.g., day soils (southern areas of the city). Plot-specific delay pools and depressions. Looking for solutions. Soil conditions vary, may not be model solutions. • As input data for studies for the formula: Design rainfall, soil conditions (water absorption), calculate how much to delay.		
What information would you like to know about stormwater, or what do you see worth storing?		• How much surface runoff can be reduced. • Surface level measurement is cheaper than flow meters	• Oils, unable to analyze with gauges? • It is a good idea to measure PAHs on biochar filters
What identifiable or measurable values do you see revealing the information you want to know?		• Conductivity correlates with the amount of salt and metals used to indicate industry-based emissions	

Are you aware of any laboratory analysis methods that can be used to measure those values?		• Small particles, turbidity, microplastics -> sample + laboratory analysis	• Self: Nutrients, phosphorus, nitrogen, soluble forms, pH, chemical oxygen demand • It is more difficult to buy from outside, researchers would be able to tell you comprehensively what
Do you know any automatic sensors that can measure those values?		• Sensor supplier ISO: GWB: https://www.gwb.fi/fi/ • The experiment was completed and will continue this spring: https://www.fi.endress.com/ (electrical conductivity, PH, Oxygen) • Manual sampling: SVSY, Saimaan Vesi- ja Ympäristötutkimus Oy, https://www.svsy.fi/	• Not currently in use. One project is planned. But getting funding for automation is hard. (ELY?) • Mikael Kraft Executive Vice President, mikael.kraft@svsy.fi, 044 732 1256 - the association has one continuous measuring device • Website contact information on the laboratory side
Do you know the limit values or ranges for analyzing and understanding the different measurable values?		No	• Ditch water values compared to lake values • The values of the lakes are compared "Water quality explanation limit values": https://peda.net/kauhava/lukiokoulutus/kauhavanlukio/pph/vlr:file/download/b046e049f6ebbf08bceceea1be9fd4e68a097eb2/Liite3-Vraen quality • On the association's website, information on the concentrations measured in Saimaa: https://www.svsy.fi/yhdistys/vesistoalueet/etela-saimaa/ • Hertta - water quality register • Comparing the quality of incoming and outgoing water on a wetland
What else should be considered in the TransformAR project when planning stormwater analysis?	• Groundwater oils, large parking areas, even a small amount of water can pollute a large amount of water • Impurities, in the sand • Quartz stone that may be present in sanding sand (?) Quartz dust released from quartz stone on construction sites and other quarrying and stone work is the most significant cause of occupational lung cancer in Finland after asbestos (Source: https://www.ecoonline.fi/blogi/tyoperaisen-syovan-torjunta)	• When turbidity begins to rise, what does it mean in this area, what components are there in the water then • Online analytics can be problematic, not maintenance free • Online parallel sampling -> eg When turbidity information is obtained, samples are taken • Electrical conductivity / turbidity could act as a trigger for manual sampling and analysis • Reduction of flow -> emissions are also reduced, lower load on the receiving water body	• Antti Haapala, ELY could be a good interviewee; he could also have experience with measuring instruments. • Water reports on the website • Measurement results by e-mail • Eurofins: Groundwater and surface water - Eurofins Finland • Kymen water and environmental research: https://www.kymijoenvesijaymparisto.fi/palvelut/

Others	• Demonstrable demo functionality and profitability: which indicators• Does real-time nutrient monitoring make sense? Correlation to solids• Nutrients dissolve in sediment -> anaerobic state, also in the pipeline network • Nitrate in soluble form (real-time monitoring)• Ammonium and sulphite -> odor nuisance• Urea (nitrogen) may be present in urban areas• Oulu, Kajaani ... by digging online • LUT has tried to analyze the oils but the results were disappointing, not found• Reactive field / reactive wall for impregnation: not just a layer of sand, various clay minerals, renovation eg every 10 years (parking lots, oil) • Sampling tubes where the sensor can be dropped, maintenance need statement -> conductivity above and below + water sample if required (same technique as for groundwater sampling) • Sampling wells are daily• The "oil" visible in the water body is often only a bacterial population• LUT / NTNU could study cameras and machine vision in oil detection • TBT or tributyltin (C12H28Sn) is an organotin compound used as a pesticide. TBT has been used, among other things, in primers for boats and ships to prevent vegetation and microorganisms from adhering to the bottom of the ship. TBT has also been used in the wood and paper industries and in industrial water systems, among others. • Decision maker tool: amount of deep infiltration 15%, shallow infiltration, 30-40% evaporation, + surface runoff -> reduction of sewage / lake share -> verified impact of stormwater treatment system • With carbon filters to irrigate plantations, however, large solids (such as cigarette butts) must be filtered out.• Research on biochar LUT, does not withstand large flows, technical structure is insufficient. Domestic. Does not bind phosphorus. Biochar may not collect the amount of solids that would be hazardous waste.• Roxia: Geosock, transporting solids away for hazardous waste treatment? Not necessarily landfillable• Polonite - a company from Imatra, KK Haapaselkä Oy (presentation Haapaselkä Oy presentation 12 04 2022.pdf) • Impact assessment: own perspective + issues perceived by stakeholders as important• Decisions about implementations!	

Questions	Southeast Finland ELY	Saimaa water and enviromental research, SVSY2
What information are you currently investigating about stormwater?	• The quality of lakes and rivers is of interest • Rainwater is not monitored by default • Measurements of water from fields at the far end • Flood water pH values, not focused here either	• This model has mechanical "wipers", a brush that cleans the optical sensors once an hour / day / now. SYKE uses these devices. Battery operated. A couple of weeks without maintenance. In clean water even every month. Quick to install and take off. • Bluetooth out data, • The season affects the need for maintenance • In Hiitolanjoki last summer • Continuous measuring device YSI: Exo2.0, 6 ports, possible to add if necessary? o GWM Engineering importer, Kouvola • Electrical conductivity, turbidity, chlorophylls, ... cyanides, pH, temperature, pressure • There is no sensor for phosphorus • There is a sensor for nitrogen, although not super-accurate, it can already fail after a year • ~ 20k € (VAT0) • Oxygen, temperature and electrical conductivity: 800 € / week (although the need was only 2 weeks) • The city measuring platform has a compressed air bottle, which makes the sensors clean. • Calibration with water sampling • Measurements of ditches, beds, rivers, wetlands • Sampling of pipelines in factory areas
For what use do you need information on the quality (/ quantity) of stormwater?		• Not currently available. Obligation on inspections of factory areas only. • Aiming for water protection, river basin rehabilitation, surveys based on ditch measurements and determining the total load -> where the load comes from, targeting wetlands and measures to the right place
What information would you like to know about stormwater, or what do you see worth storing?	• Oxygen content and pH • In stormwater, especially electrical conductivity -> impurities • Metal lengths are usually of interest • Oil compounds are also of interest • Peatlands measure particulate matter concentrations in outgoing waters, different from solids measurement, but correlate. • Contamination of untreated wastewater with stormwater -> covers all other contaminants • Plastics • The presence of intestinal bacteria would reveal a mixture of wastewater and stormwater	• Pesticides? • How much of the total load comes from stormwater (Lahti has done research on this) • Load during recreational use

Do you know any automatic sensors that can measure those values?	• Rakholanjoki EHP-Environment (Oulu) equipment, electrical conductivity, turbidity, clophylls, temperature, nitrate nitrogen, SAC via COD (chemical oxygen demand). Used for ELY from the Finnish Environment Institute. EHP Environment Continuous environmental measurement solutions o Last fall measured well with a "grade of 8" o Winter "grade 6.5" o The same device was on the Russian side without maintenance -> the results are almost useless o Weekly maintenance in turbid waters (debris removal, etc.), normally "from late June to late September, once every two months" o Wireless data transmission (Telia 3G / 4G) and battery + solar panel o Quality assurance service 120 € / month, incl. data o Compressed air blown ended, data month useless o The Lappeenranta measuring platform is from this same supplier • Northwest Consulting, Mikko Kirkki entrepreneur, Shungiitti? Luode Consulting Oy - Water quality and measurement technology expert o Phosphorus measurement via turbidity values o There is no meter that directly measures phosphorus o On the coast, phosphate phosphorus can be measured with a device. • GVM Engineering (Kuopio) also has sensors. American supplier. (Juha Lyytikäinen) GWM-Engineering :: Home o Some acquired equipment cost 18k € (2002) • Peat bogs measure particulate matter concentrations in outgoing waters, different from solids measurement • YSI | Water Quality Sampling and Monitoring Meters and Instruments for dissolved oxygen, pH, Turbidity	• Available for loan? Price?
Do you know the limit values or ranges for analyzing and understanding the different measurable values?	• Comparison with wastewater concentrations? • Quantities: dilution to a large volume of water • In high water concentrations -> more effects on water • Proportionality to the receiving water body, greater impact in a smaller water body	• River basin district surveys, total load in sub-catchment areas: how much total load comes from certain urban areas • Comparison of results with lake reference values • For example, in ditches concentrations in a different class than in lake water
What else should be considered in the TransformAR project when planning stormwater analysis?	• Quality of stormwater from different catchments, what kind of load? • Water retention in the same structure -> reduction of surface load and equalization of runoff peaks	
Others	• The quantity and quality of water are both affected. • Sensors: "Continuous" • Once a month there are bottle samples • Wastewater entering stormwater, reviewing the quality of stormwater may not be enough, reviewing the functioning of the system, direct overflows, risk assessment? More comprehensive screening of what can be found (heavy metals, etc.) in different catchment areas. The industry has studied what substances are used and what emissions are generated. Diffuse load. • The mapping of total risks requires monitoring from several locations • Monitoring the water quality of sewers • Laborious maintenance and upkeep of measuring equipment • When heavy rains start, catching the peak with continuous measurement (not possible with manual), load relative to the beginning of heavy rain	• Lahti has made some filter solutions, the Water Lake Foundation and the University of Helsinki • Green roofs • Online analysis results service: https://v2lextranet.svsy.fi/Account/Login >>> Tia Velin / Niina (on leave) • Obligation monitoring automatically in the Hertta database (SYKE): data source via the interface? Open environmental information systems - syke.fi

Questions	Lahti City	NTNU
What information are you currently investigating about stormwater?	• Measurements in two categories: o to assess the impact of the load, what kind of load, continuous measurement of rainwater in the downtown area. o Measurements related to the performance of individual structures, not continuous measurement. • Impact assessment -> levels of contaminants • Continuous measurements in the stormwater line • The autosampler collected pooled samples 1 / week • Large booth, on top of the stormwater drain. • Flow sensor, subsamples based on cubic volume, samples in the refrigerator inside the cabinet. • Weekly collected and analyzed in the lab • Expensive: Sensors were cleaned once a week, lab samples once a week • Concentrations of contaminants in stormwater vary, sampling either from a pooled sample, a sample from a mixed pooled sample. Or take a lot of individual samples -> more expensive. Individual samples may give different results. • Concentration without volume does not indicate efficacy (except for a decrease in concentrations for a single structure) -> flow measurement • Luode supplied the equipment, in Lahti on loan from Helsinki University: https://www.luode.net/laitteistomyynti/ • Derivative quantities turbidity and electrical conductivity: By turbidity measurement adheres to solids content, electrical conductivity to metals	
For what use do you need information on the quality (/ quantity) of stormwater?	• Evaluation of effectiveness • Nutrient and heavy metal load, nitrogen and phosphorus, verification by measurements • Functionality of structures: before and after situation, 4 times a year aggregate samples from incoming and outgoing, sampling intervals from permit conditions, sampling after heavier rain, obligation monitoring • Need to rehabilitate the filtration structure when it loses water permeability (accumulation of solids), living cleaning efficiency • Filtration: field 3 blocks: filter sand, leca crushed stone, filtralite: https://www.filtralite.com/en	
What identifiable or measurable values do you see revealing the information you want to know?	• The range must be verified with reference samples in the lab • You promised to send a final report and a newspaper clip from Vesitalouslehti + research plan	
Do you know any automatic sensors that can measure those values?	• Derivative quantities and indirect measurements (turbidity and electrical conductivity) • Sensmet: https://www.sensmet.com/ Toni Laurila • 2019-2020 Smart & clean project, street pilot in Espoo, for measuring elements in stormwater, in trial use a few months, not cheap, project ended a couple of years ago, new measurement technology? Preliminary results are promising.	• No flow meters in use • New lab, many sensors to be tested, not yet specialized water sensors • Custom sensors to measure unique, novel things

Do you know the limit values or ranges for analyzing and understanding the different measurable values?	• Range of the catchment area, in practice the correlation between turbidity and solids • Specific load figures per land use, solids load and metals, general level • Material in the final work master_Järveläinen_Jarmo_2014.pdf (aalto.fi)	
What else should be considered in the TransformAR project when planning stormwater analysis?	• Evaluation of the effectiveness of the structure, i.e how the quality of stormwater changes in the structure • Agreed division of labor for sampling and maintenance • For example, solids determinations must be performed in the lab on the same day. Someone needs to be ready to go take samples at the right time. • Not real-time image but by modeling (hydraulic model) + qualitative risk areas (analysis of existing data based on risk targets and route to the receiving water body, water body sensitivity level) • The City of Helsinki (Hulakas project) commissioned a study as a consultant, identifying qualitative risk areas • Practical technical implementation of the pilot supports the practical goal, measurements can be carried out, collection piping in the filtration structure -> sampling possible (sampling well), sampling of incoming water + continuous measurement, flow measurement not possible in case of too small pipe • Flow measurement based on surface height with pressure sensor, ultrasonic sensor on the top or bottom of the pipe -> requires a certain water level to work	
Others		• What are heavy metals? • Microplastics difficult to measure by continuous measurement, but interesting • Coordinating role in T4.4 • Available open source APIs (T4.1.2) • Review of existing solutions? • Develop something very cheap to measure Turbidity? • Volume: develop a

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Others		• What are heavy metals? • Microplastics difficult to measure by continuous measurement, but interesting • Coordinating role in T4.4 • Available open source APIs (T4.1.2) • Review of existing solutions? • Develop something very cheap to measure Turbidity? • Volume: develop a solution to estimate the volume of run off waters o To estimate the water level, camera on street surface, estimating the run off volume from the image, hydrolocigal models? • Droplet? • Next meeting 20/6, NTNU to present slides on technical solutions

BALTFLOODS, Baltic Flood Resilience and Digital Solutions

D 1.1 Annex B: Data Management Plan

AUGUST 31, 2025

Interreg
Baltic Sea Region

Co-funded by the European Union

RESPONSIVE PUBLIC SERVICES
BALTFLOODS

This project is co-funded by the European Union through the Interreg Baltic Sea Region Programme.

About BALTFLOODS Project

BALTFLOODS aims to enhance flood preparedness and mitigate runoff pollution in cities across the Baltic Sea region by leveraging digital and technological solutions and engaging citizens as key stakeholders. The project addresses three main challenges aligned with the thematic scope of Priority 1 of the Interreg Baltic Sea Region Programme, particularly Objective 1.2. Firstly, BALTFLOODS will improve disaster preparedness and response to floods by implementing advanced monitoring systems that provide real-time data for timely interventions, benefiting local and national public authorities, infrastructure owners, and service providers. Secondly, the project will decrease the discharge of polluted stormwater, thus enhancing environmental quality and public health. This involves monitoring water quality through innovative approaches that support environmental and public health goals. Thirdly, BALTFLOODS will increase community engagement in flood and water pollution issues through participatory tools, empowering citizens and educational institutions to take an active role in environmental stewardship. By fostering a well-informed and proactive community, the project builds societal resilience to environmental threats. Transnational cooperation will be essential to facilitate knowledge exchange, policy alignment, and resource pooling to enhance the scalability and sustainability of the solutions, ultimately benefiting urban populations and the Baltic Sea Region ecosystem.

Learn more about the project:
www.interreg-baltic.eu/project/baltfloods

Project Name	**Baltic Flood Resillience and Digital Solutions**
Project No.:	#C063
Submission Date	August 31, 2025
Author	Steven Yves Le Moan, Norwegian University of Science and Technology Marcos Xosé Álvarez Cid, NTNU, Norwegian University of Science and Technology

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Introduction

The BALTFLOODS project is a transnational initiative to enhance urban flood resilience and reduce polluted stormwater runoff in Baltic Sea region cities. This Data Management Plan (DMP) describes how all project data will be collected, used, stored, accessed, and preserved in accordance with European FAIR principles – making data **Findable, Accessible, Interoperable, and Reusable**. It also ensures compliance with relevant regulations and ethical standards, notably the EU General Data Protection Regulation (GDPR) for any personal data handling. The DMP provides guidelines for partners on responsible data management and outlines the project's data lifecycle from creation to long-term archiving. All consortium partners are committed to open science practices, meaning that **whenever possible, project outputs and datasets will be made openly available** for scrutiny and reuse by external stakeholders. Any exceptions (e.g. due to privacy or security constraints) are documented in this plan.

In BALTFLOODS, a wide array of data is leveraged to support flood monitoring, modelling, citizen engagement, and decision-making. **Data types span** satellite remote sensing imagery, real-time IoT sensor measurements, laboratory water quality analyses, citizen-contributed reports (including social media inputs), aerial/drone photographs, and historical municipal records. These diverse data streams feed into an integrated digital platform based on the FIWARE open-source framework, enabling real-time exchange of information for flood alerts, water quality tracking, and public dashboards. Throughout the project, we emphasise data quality, interoperability, and privacy – ensuring that data are accurate and useful for stakeholders while protecting sensitive information. The following sections detail the data management practices per work package (WP) and the measures in place to uphold the FAIR principles, data governance, ethical considerations, and long-term stewardship of BALTFLOODS data.

1. Data Summary by Work Package

1.1 WP1 – Preparing Pilot Frameworks and Strategies

Main purpose of data collection: WP1 focuses on preparatory activities to design the project's pilot solutions and methodologies. Data collection in this phase aims to gather background information and stakeholder input needed to plan the pilots and evaluation framework. Key purposes include: (1) assembling knowledge on existing flood management practices and technologies, (2) understanding stakeholder requirements and local context, and (3) developing standards and protocols for data integration and citizen engagement.

Types of data: This work package primarily deals with *information* and reference data rather than raw sensor readings. It includes literature and **desk research data** on flood management models, water quality standards, and best practices from past projects. It also involves **stakeholder input** collected through workshops and interviews (e.g. notes, survey responses) to shape the citizen engagement strategy. Additionally, WP1 compiles **baseline data** about the pilot cities (e.g. maps of flood-prone areas, existing sensor networks, and relevant climate statistics) to inform planning. Any existing **open datasets** from partners (such as national environmental databases or prior project results) are gathered for context. Overall, WP1 deals with textual and numerical data stored in documents, spreadsheets, and presentations – for example, reports outlining remote sensing tool designs and data governance guidelines.

Re-use of data: All major outputs of WP1 – including the *Framework for Piloting and Evaluating* (D1.1), the *Data Systems Integration Plan* (D1.2), the *Citizen Engagement Strategy* (D1.3), and the *Pilot Implementation Plan* (D1.4) – are public deliverables. These reports (and their supporting data) will be made openly available for re-use. Within the project, WP1 findings feed directly into WP2 implementation activities (providing the reference architecture and engagement methods). Externally, the frameworks and standards developed can be reused by other cities or projects looking to implement similar flood monitoring and citizen science approaches. For example, the data standards and governance guidelines from WP1 establish formats and protocols that ensure compatibility and **future reusability across different contexts**. All background data compiled (such as bibliographies, case studies, or stakeholder lists) will be available alongside the reports to maximise their utility beyond the consortium.

Data origin: The data in WP1 comes from **existing sources and stakeholder contributions**. Literature and case study data are sourced via academic publications, policy reports, and open databases (e.g. EU publications on nature-based solutions, prior Interreg project outputs). Some technical inputs come from partners' prior work – for instance, sensor specifications or remote sensing algorithms contributed by research partners. *Stakeholder inputs* originate from activities like the multi-partner workshops (involving universities, municipalities, and NGOs) and interviews with associated partners across the Baltic region. These stakeholders were informed of how their input would be used in the project's design, and any personal data (e.g. names in attendance lists) are handled under GDPR-compliant consent processes. No new sensors or field measurements are deployed in WP1; rather, this phase integrates existing knowledge and expert insights.

Expected data size: Data volume in WP1 is modest. The outputs consist of several reports (each a few dozen pages, in Word/PDF format) and supporting files like spreadsheets or slide decks. We estimate a total on the order of a few **hundred megabytes** of files for WP1. This includes text documents (typically a few MB each) and possibly some images or diagrams. There may also be small datasets (e.g. an Excel file cataloguing stakeholder contacts or a table of pilot site indicators), but these are not large – likely a few MB. In total, WP1 data might amount to only a few GB at most, mainly due to inclusion of high-resolution figures or GIS shapefiles used in planning.

Data utility: The preparatory data in WP1 is crucial for guiding the project's next steps and has value for others beyond BALTFLOODS. Internally, these data inform WP2 and WP3 by ensuring that implementation is based on proven methods and stakeholder needs. Externally, the framework and plans serve as **reference models** for other municipalities in the Baltic Sea Region and beyond, illustrating how to set up integrated flood monitoring and engagement initiatives. For example, a city interested in replicating BALTFLOODS can re-use the data standards and citizen engagement frameworks from WP1 to jump-start their own planning. Thus, while WP1 data is largely qualitative and foundational, it provides a **shared knowledge base** that underpins the project and can be readily transferred as best practices to a wider audience (policymakers, city planners, and researchers focused on climate adaptation).

1.2 WP2 – Pilot Implementation and Data Collection

Main purpose of data collection: WP2 is the core of BALTFLOODS where new data are generated through pilot implementations in two cities (Lappeenranta, FI and Gjøvik, NO). The main purposes of data collection in WP2 include:

- **Real-time environmental monitoring:** Deploying sensors and remote sensing to gather live data on water levels, flows, and water quality, improving situational awareness for flood preparedness.
- **Flood modelling and analysis:** Collecting data to feed hydrological models and water quality models, enabling simulation of flood scenarios and pollution dispersion under various conditions.
- **Flood alerting and response:** Utilizing data (e.g. threshold exceedances) to trigger flood warnings and inform emergency response measures, protecting communities.

- **Public information dashboards:** Populating open dashboards and visual tools with up-to-date flood and water quality data so that authorities and citizens can track conditions and risks in near real time.
- **Research and evaluation:** Capturing comprehensive datasets from the pilots to assess the effectiveness of interventions (e.g. new overflow devices, nature-based solutions) and to support scientific research on urban flooding and stormwater pollution.

In summary, WP2 data collection is aimed at **both operational use (monitoring & alerts) and knowledge generation (modelling & evaluation)**. By integrating these pilots' data streams, the project demonstrates how digital technology and citizen input can improve flood resilience on the ground.

Types of data: The pilots produce a **diverse range of data types**, reflecting the multi-faceted approach of BALTFLOODS. Key data types include:

- **Satellite imagery and remote sensing data:** High-resolution optical and radar images (e.g. Sentinel-2 multispectral and Sentinel-1 SAR from the Copernicus programme) covering the pilot areas. These support flood inundation mapping and water quality assessment (e.g. turbidity or algal bloom indicators) from space. Derived products like *flood extent maps*, *land use classifications*, and *water quality index maps* (GeoTIFF rasters) are generated from this imagery.
- **IoT sensor data:** Real-time measurements from Internet-of-Things sensors installed in the field. This includes **hydrological sensors** (water level in rivers, storm drains, flow rates, rainfall intensity) and **environmental sensors** (water quality probes measuring turbidity, conductivity, temperature, etc.). These sensor readings are typically time-series data collected at regular intervals (e.g. minutes) and ingested in JSON/NGSI-LD format via the context broker. The pilots will also integrate data from existing municipal telemetry systems (SCADA), such as sewer overflow alerts or pump statuses, where available.
- **Laboratory water quality data:** Periodic lab analyses of water samples from the pilot sites provide detailed **water chemistry and microbiological data**. For example, lab tests measure pollutant concentrations (nutrients, heavy metals, organics) and indicators like E. coli counts that sensors cannot directly detect. These lab results serve as ground-truth for sensor and satellite data and are recorded in structured tables (e.g. Excel) with metadata on sample time, location, and parameters measured.
- **Citizen-contributed data:** Citizens play an active role in data collection through the project's mobile app and engagement activities. The data include **crowdsourced incident reports** (e.g. a citizen reporting a flooded street or polluted runoff, with text descriptions and location) and **photos or videos** uploaded by the public showing flood situations or water conditions. Social media content mentioning floods (e.g. Twitter posts) may also be scraped under ethical guidelines to augment situational awareness. All citizen-contributed data is tagged with time and location, and personal identifiers are handled carefully (e.g. only stored internally in the app database, not exposed publicly).
- **Drone and CCTV imagery:** To complement satellite data, **drone footage** and CCTV camera images are collected during flood events or heavy rainstorms in the pilot areas. Drones can capture aerial video of flooded neighbourhoods or construction sites, providing high-detail visual evidence. CCTV (such as city traffic cameras in flood-prone spots) can supply continuous imagery of water levels. These yield unstructured image/video data (stored as MP4, JPG, etc.) that are later analysed for water depth estimation or simply used for documentation and community awareness.
- **Historical data and records:** The project compiles **historical municipal records** related to flooding and stormwater to provide context. This includes past flood incident logs, damage reports, rainfall records, drainage network maps, and any existing studies from city archives or national databases. Such data helps in model calibration (e.g. validating flood models against a known past event) and in understanding long-term trends. Spatial datasets like historical floodplain maps or land use changes (often in GIS formats) are part of this category.

All these data types are integrated under the WP2 pilot implementation. **Standard data formats** are used for each type to ensure consistency: for instance, GeoTIFF for raster maps, GeoJSON for spatial vector data, time-series sensor data in JSON (NGSI-LD) or CSV for exports, and images/video in common media formats. This variety of data paints a comprehensive picture of the pilots, from on-the-ground sensor readings to high-level satellite views and human observations, enabling robust analysis and cross-validation of flood events and water quality issues.

Re-use of data: The data collected in WP2 will be **actively reused within the project and beyond**. Internally, WP2 datasets feed into WP3 evaluation and knowledge transfer activities – for example, sensor and citizen data are analysed to produce performance metrics, and notable images or case studies are included in best-practice handbooks. All *validated, non-sensitive data* from WP2 will be prepared for external re-use as open data where feasible. This means environmental monitoring datasets (e.g. time-series of water levels or water quality) and geospatial outputs (flood maps, etc.) will be made available to other researchers, city planners, and the public. Such data could be reused to inform flood risk assessments in other regions or to conduct comparative research on urban flooding. Indeed, one aim is that **other Baltic cities can reuse BALTFLOODS pilot data** as reference when implementing similar solutions.

Some data, like raw sensor feeds, will be continuously accessible via open APIs during the project for real-time reuse (e.g. a developer could build a third-party app that pulls the data). After the project, key datasets will be archived for long-term reusability (see Section 3.4). No patents or proprietary restrictions will hinder re-use – the project will not seek patents on any data or tools, and data will be released under open licenses without embargo. *Personal or sensitive data* (such as individual user reports with identifying details) will **not** be openly shared at the individual level, to protect privacy. Instead, those are aggregated or anonymised (e.g. the number of citizen reports per area, but not names) before any public release. In summary, WP2's data is treated as a valuable public good: after serving immediate operational needs, it remains a resource for the broader community, supporting education, further research, and evidence-based policy on flood management.

Data origin: WP2 data originates from a combination of **project-deployed systems and external providers**. The primary sources are:

- **In-situ pilot installations:** Sensors installed or utilized by the project in Lappeenranta and Gjøvik (e.g. water level sensors in manholes, water quality probes in lakes, "V-overflow" monitoring modules on storm drains) generate continuous data streams. These are either new IoT devices introduced by BALTFLOODS or existing municipal sensors integrated via connectors. Data from city **SCADA systems** (supervisory control and data acquisition), such as pumping station logs or overflow alarms, are pulled into the
- **Earth observation providers:** Satellite data is sourced from the **Copernicus Open Access Hub** (Sentinel-1, -2, etc.) and possibly other platforms like NASA or national satellite archives. These providers offer open access to raw imagery, which the project downloads (often via automated scripts) and processes. Aerial imagery may come from drones operated by project partners or local authorities, while weather radar tiles and forecasts come from **national meteorological services** (e.g. the Finnish Meteorological Institute, Norwegian Meteorological Institute) via their open data APIs.
- **Citizens and stakeholder contributions:** Citizen data originates directly from the **BALTFLOODS mobile application** and web portals used in the pilot cities (where participants submit reports). Additionally, data is gathered through citizen science initiatives (e.g. school projects measuring water samples) and social media monitoring (tweets, etc.) under consented conditions. The origin of social media data is the public posts by citizens in the region (accessed via platform APIs in compliance with terms of service). All participants are informed about data usage, and explicit consent is sought when required (for example, participants in school monitoring activities sign consent forms through their schools).
- **Laboratories and agencies:** Water sample analyses are performed by accredited environmental labs (e.g. a city's environmental agency lab or university labs), which produce digital reports of the results. The data origin here is the **laboratory instruments** and expertise. Similarly, some historical data comes from **municipal archives** and **national agencies**: for instance, flood event records might come from a national emergency management database, and climate statistics from institutes like SYKE (Finnish Environment Institute) or NVE (Norwegian Water Resources and Energy Directorate). These are gathered through formal requests or via open data portals maintained by those agencies.

In integrating these sources, the project ensures provenance is recorded – each dataset is tagged with its origin (sensor ID, provider name, etc.) so that users of the data know where it came from.

Expected data size: WP2 is data-intensive, and we anticipate a **large volume of data** accumulating over the project's duration. Rough estimates are: time-series sensor data from dozens of devices logging every few minutes can produce several **gigabytes** of data per year (especially if images or complex sensor payloads are included). High-resolution satellite images are on the order of 0.5–1 GB each; with regular acquisitions for two cities, this could be tens of gigabytes of imagery. Drone videos and photos might add a few more gigabytes (depending on frequency of flights). Citizen reports (being mostly text and small images) are lighter, perhaps a few tens of megabytes in total. In addition, the integrated database (context data plus historical records) may reach a few gigabytes by storing all sensor histories and metadata. In total, WP2 data might amount to **tens of GB** over three years, potentially up to the low hundreds of GB if we include all raw multimedia and external datasets. Sufficient storage has been provisioned for this volume (the platform's object store can easily scale to hundreds of GB). The project team will continually monitor storage use to ensure capacity for peak events (e.g. heavy storm generating a burst of sensor and citizen data). Compression and downsampling strategies will be applied where appropriate (e.g. archiving older raw data in compressed form while keeping recent data readily accessible).

Data utility: The datasets from WP2 have immediate and long-term usefulness. In the immediate term, they enable **evidence-based decision-making** in the pilot cities – for instance, city engineers can use sensor and model data to pinpoint where drainage upgrades are needed, and emergency services use flood alerts to allocate resources. The public utility is also significant: citizens gain access to realtime information about local flood risks and water quality (empowering them to take precautions and to trust the city's interventions). From a broader perspective, WP2 data contribute to scientific understanding of urban floods and stormwater pollution under climate change. Researchers can use the open data to validate models or to compare with other regions' data, strengthening regional flood models. **Policy-makers and planners**

can leverage these data to justify investments in infrastructure (with the pilots' data as proof-of-concept of certain solutions' effectiveness). Additionally, the data support education and awareness; for example, local universities or schools might incorporate the live data streams into coursework on environmental science. The transnational value is high: by sharing WP2 data among Baltic Sea region networks, the project helps build a regional repository of flood resilience knowledge, where cities learn from each other's data. In sum, WP2 data is a cornerstone of the project's impact – not only solving problems locally but also informing and inspiring actions across the region in pursuit of smarter water management and climate adaptation.

1.3 WP3 – Evaluation, Knowledge Transfer and Data Sharing

Main purpose of data collection: WP3 is dedicated to evaluating the pilot outcomes and transferring the knowledge gained to other stakeholders and regions. The data collection in this phase serves several purposes: (1) **Pilot performance evaluation** – gathering metrics and evidence from WP2 to assess how well the solutions performed (e.g. reduction in flood incidents, improvements in water quality indicators); (2) **Stakeholder feedback** – collecting data from involved stakeholders (municipal staff, citizens, associated partners) on their experiences, satisfaction, and suggestions regarding the pilot measures; (3) **Best-practice synthesis** – compiling information needed to produce guidelines, handbooks, and policy recommendations (this may involve collecting additional data from external case studies or literature to complement the pilots); and (4) **Upscaling and transfer** – obtaining data that helps adapt the solutions to other contexts (for example, data on local conditions in replication sites or inputs from transnational workshops). Essentially, WP3's data activities are about **learning and generalising** from the pilots: ensuring that all relevant lessons are captured quantitatively and qualitatively, and that this knowledge is packaged for others to use.

Types of data: The data handled in WP3 includes both quantitative evaluation data and qualitative information for knowledge transfer:

- **Performance metrics and indicators:** Structured data summarising the pilot outcomes. For each pilot solution, key performance indicators (KPIs) are collected – e.g. number of flood events before vs. after intervention, volume of stormwater treated, pollutant concentration reductions observed, response time improvements, citizen engagement levels (number of reports, app usage stats). These are typically assembled in spreadsheets or databases. For example, the project might maintain an evaluation matrix where each pilot is a row and various impact metrics are columns, filled with values drawn from WP2 data analysis.
- **Evaluation reports and case studies:** Analytical narratives (textual data) describing each pilot's results, challenges, and success factors. These reports often include embedded data like charts, tables, and maps produced from WP2 datasets. They serve as intermediate data – feeding into the creation of public-facing deliverables like the *Best Practices Handbook*. While the reports themselves are documents, the underlying data (e.g. chart data points) are kept in an accessible form for transparency.
- **Stakeholder feedback data:** This includes responses from surveys, interviews, and workshops conducted to evaluate the pilots and gather external perspectives. For instance, after pilot implementation, **survey questionnaires** might be distributed to citizens or city employees to rate the effectiveness of the new tools. Similarly, **focus group transcripts or interview notes** with stakeholders (e.g. municipal decision-makers, utility operators) are collected to identify what worked and what barriers exist. These qualitative data are anonymised and analysed for common themes. They may be stored as text (interview transcripts), or as coded data (survey answers in spreadsheets).
- **Training and workshop outputs:** WP3 involves knowledge-sharing events like policy labs, regional workshops, and educational sessions (as indicated by project outputs O2.2, O2.3 etc.). Data from these events include participant lists (with affiliation and sector, for reporting reach), feedback forms from attendees, and content produced during sessions (e.g. flipchart notes, collaborative maps). For example, a regional workshop might yield a set of identified best practices or action items, documented in a summary report. These outputs are semi-structured data capturing insights from multi-actor discussions.
- **External case comparison data:** To enrich the project's recommendations, WP3 may collect data from *external pilot cases or related projects* in the Baltic Sea Region. This could mean gathering published results from another city's flood pilot (e.g. statistics from a past Interreg project, or data shared by an Associated Organisation in Germany, Latvia, Sweden, or Ukraine). Such data helps demonstrate the **transnational applicability** of BALTFLOODS solutions. It might be as simple as a table of comparative indicators (like cost per device, reduction in flood volume achieved in another city's project) included to benchmark BALTFLOODS pilots.

Overall, WP3 deals with data that distils and contextualises the raw information from WP2. It combines **numerical data** (metrics) with **narrative data** (lessons learned, stakeholder perspectives) to form a comprehensive evidence base for the project's conclusions and recommendations. All data types here are carefully documented, since they will inform official deliverables like policy briefs and best-practice handbooks intended for wide dissemination.

Re-use of data: Data produced in WP3 is intended to be **highly reusable**, as one of this WP's goals is to share knowledge broadly. Within the consortium, WP3 data (like evaluation metrics) are used to refine the project's approach and to inform any adjustments during the project's later stages. More importantly, the outputs packaged in WP3 – such as the *Best Practices Handbook*, policy briefs, and training materials – are designed for uptake by external stakeholders (municipalities, policymakers, educational institutions). All underlying data that support the recommendations in these materials will be made available for transparency and reuse. For example, if a policy brief cites a statistic about flood response time improvement, the dataset or calculation behind that statistic will be published (unless it contains confidential information). **All WP3 deliverables are public** and will include or reference the data behind them so that other parties can reuse the findings.

Additionally, the data collected on stakeholder feedback and engagement (with personal identifiers removed) can be reused by other researchers studying public engagement in environmental projects. The project also anticipates that the evaluation data could be reused in meta-analyses or future initiatives – for instance, a follow-up project could take BALTFLOODS' results data and combine it with new pilots to further generalise best practices. Therefore, we ensure WP3 data is archived in an accessible form after the project. Some of the WP3 data (like training session feedback) might not be broadly interesting beyond the project team; those will still be stored internally for accountability, but the emphasis is on reusing the **core insights and evidence** from the pilots to maximise impact. In summary, WP3's data is captured and shared in a way that **any city or researcher can pick it up and learn from BALTFLOODS**, accelerating the transfer of solutions across the region.

Data origin: WP3 data is drawn from both the project's own activities and external inputs:

- **Pilot result data (internal origin):** A significant portion of WP3 data originates from WP2, i.e., it is *derived from the pilots*. The source for performance metrics is the sensor readings, models, and citizen data that WP2 produced (already described above). These are processed and summarised by the BALTFLOODS team to generate the evaluation indicators (e.g. computing % reduction in overflow events from raw counts). Thus, the origin is ultimately the pilot infrastructure and participants but curated by the project's analysts in WP3.
- **Stakeholder feedback (internal origin):** Feedback data comes directly from participants engaged by the project – for example, city officials who participated in evaluation meetings, or citizens who filled surveys. The project itself is the **primary data collector** here, using tools like SurveyMonkey for questionnaires or recording notes from workshops. In some cases, partners in each country lead the data collection from their local stakeholders (for instance, CEEV and GU collecting feedback in Germany/Sweden, LUT in Finland, NTNU in Norway). Each respondent's input is considered to originate from that person; the project aggregates these individual inputs into collective findings. All personal response data is gathered with consent and stored securely, as these are human-subject data.
- **External benchmarks and case data (external origin):** When WP3 includes data from outside (e.g. another city's pilot results), the origin is typically **published sources or direct partner sharing**. For example, if we incorporate a data point from City X's flood project, the origin might be a public report by City X or a dataset that City X's team shared with BALTFLOODS. We document such origins in our reports (citation of source). Additionally, associated organisations in the project consortium might provide data from their cities for comparison – in that case, the origin is that city's authorities or databases. All externally sourced data is credited and checked for permission (we ensure we have the right to use it in our outputs, which is usually granted since these are for public benefit).

By combining these sources, WP3 generates a synthesized knowledge base that is richer than what BALTFLOODS alone could produce, tying in external experience to bolster the transferability of our results.

Expected data size: The volume of data in WP3 is moderate. Numerical evaluation datasets (like KPI tables) are relatively small (kilobytes to a few MB), and textual feedback data (surveys, transcripts) likewise. The polished outputs (reports, handbooks, presentations) will be a few MB each in document form. If we record any workshops (audio/video), those files could be larger, but typically such recordings are not kept long-term due to privacy – instead we store written summaries. All told, WP3 might encompass a few **gigabytes** of data at most, largely driven by any included multimedia or if a large number of high-resolution graphics from WP2 are embedded in reports. For instance, a best-practices handbook PDF might be 20 MB with images. The supporting spreadsheets and text files would be minor in size. We anticipate the entire WP3 dataset (including all reports and raw analysis files) to comfortably stay under 10 GB. It's worth noting that by WP3, much of the heavy data (like raw sensor readings) has been distilled, so the data here is information-dense but storage-light. We will still organise and archive it systematically since even small files can be crucial for transparency.

Data utility: WP3's data is arguably the most **impact-oriented** – it directly fuels the project's legacy and influence. The utility of this data lies in how it captures the lessons and evidence from BALTFLOODS in a form that others can use. City planners and public authorities in the Baltic Sea Region (and beyond) can use the evaluation results and best-practice guidelines to inform their policies and investments (e.g. seeing quantified benefits of a certain flood monitoring approach can justify funding it elsewhere). Educational institutions can use the case studies and data in curricula for environmental management, giving students real-world examples. Moreover, networks like the Union of Baltic Cities or regional climate adaptation working groups can draw on the WP3 outputs to advocate for scalable solutions – essentially WP3 data helps *bridge the gap* between demonstration and wider adoption. By providing solid data-backed evidence, we make it easier for target groups to trust and implement the recommended measures. On a research level, the consolidated data from WP3 (which might be published as an open dataset alongside a journal paper or as part of the project's Zenodo community) will be useful for meta-analyses of climate adaptation interventions. Finally, WP3 data – because it is packaged in accessible formats – serves as a **reference library**: future projects can avoid "reinventing the wheel" by consulting BALTFLOODS' outcomes data to design their methodologies. In essence, WP3 ensures that the data journey that started in WP2 ends in actionable knowledge that remains accessible and beneficial long after the project concludes.

(Note: WP3 of BALTFLOODS covers project management and communication. It generates primarily administrative data (e.g. meeting minutes, participant lists) and communication outputs (website, newsletters). These are mostly outside the scope of research data and not detailed here; any public communication materials are of course openly available, while personal data of project members or event attendees are managed internally per GDPR.)

2. FAIR Data Management

In line with the FAIR principles, BALTFLOODS is committed to making its data **Findable, Accessible, Interoperable, and Reusable** to the greatest extent possible. The following sections (3.1–3.4) detail how the project's data handling practices align with each FAIR component.

2.1 Findable Data

To ensure data is *findable* by consortium members and external users, BALTFLOODS will publish its datasets and outputs in a way that they can be easily discovered and identified. The majority of BALTFLOODS deliverables and data products will have a **"Public" status** and will be made available online. In fact, virtually all final deliverables from the technical WPs are intended to be public, meaning they will be posted on the project's website and (where applicable) through the Interreg Baltic Sea Region programme's result dissemination channels, making them indexed and searchable via common search engines. For example, a report or dataset released on our website will be accompanied by descriptive text so that Google can index its content, improving findability by keywords (e.g. a search for "Baltic flood sensor data" would surface the relevant BALTFLOODS data page).

Each significant dataset or document will be assigned a **unique identifier and metadata** to aid findability. We will follow a clear naming convention that includes the project acronym, work package or deliverable number, and a descriptive title. For instance, a dataset of sensor readings might be titled "BALTFLOODS_WP2_SensorTimeSeries_Lappeenranta_v1.csv" – this consistency helps both humans and machines identify the project source. Moreover, all public deliverables will feature a cover page or metadata section listing key information: project name, deliverable title, authors, partner organisation, date, version, and an abstract. This metadata ensures that even if files are separated from the website, they carry context with them. We also intend to tag datasets with relevant **keywords** (e.g. "flood, water quality, IoT, Baltic Sea") in any repository or catalogue we use, which further enhances discoverability through domain-specific portals.

Where feasible, we will use established repositories or data catalogues (for instance, Zenodo or a national open data portal) to publish datasets with **Digital Object Identifiers (DOIs)**, providing a persistent and citable reference. If a dataset is too large or updated too frequently for static repository deposition (e.g. an evolving sensor dataset), we will ensure the latest data is accessible via the project API and that a snapshot is archived periodically with an identifier. Additionally, the contact details of dataset owners (typically the lead author or data steward) will be provided in metadata. This allows any interested party who discovers the data to reach out for clarifications or further information, thereby increasing the functional findability of the data (not just finding the file, but finding someone who can explain it).

In summary, BALTFLOODS data will be easy to locate: our website will serve as the primary hub with a dedicated "Data & Outputs" section listing all available datasets and documents, each with clear descriptions. This site will remain live for several years post-project, and its contents will be indexed by search engines. By providing rich metadata and using standard identifiers and naming, we ensure that anyone searching for relevant flood resilience data will be able to find the BALTFLOODS outputs readily.

2.2 Accessible Data

BALTFLOODS is committed to making data *accessible* to users of various kinds (project internal, external public, machines, etc.) while respecting security and privacy constraints. **By default, all research data and results will be made openly accessible** either immediately or after minimal processing (e.g. anonymisation if needed). We will publish datasets through open channels (project website, open data portals) so that no special login or affiliation is required to obtain them. For instance, environmental sensor data and final maps will be downloadable in common formats (CSV, JSON, GeoJSON, PDF reports) without any paywall or proprietary software requirement. Access does not require any unique or costly tools – standard software like a web browser, PDF reader, or spreadsheet program is sufficient to view and use the data. Where data are made available via an API (e.g. real-time data through the FIWARE context broker), the API will be documented and publicly reachable (with perhaps an API key registration if needed to monitor usage, but this will be free and open to anyone).

Not all data can be made openly accessible in its raw form. Certain datasets—particularly those containing **personal data or sensitive municipal information**—require controlled access. Examples include raw citizen reports containing personally identifiable information (PII), or operational telemetry that municipalities do not wish to expose. In these cases, BALTFLOODS will:

- Publish **anonymised or aggregated versions** for open access (e.g., incident locations shown as generalised points without names or addresses).
- Keep sensitive datasets available only to **project partners via secured internal repositories**, governed by consortium agreements.
- Ensure proper **backup and archival** for restricted data, hosted on partner institutional servers and aligned with national data retention rules.

Long-term accessibility is a key priority. BALTFLOODS aims at maintaining a **"Data & Outputs" hub** at least three years post-project, with static datasets archived in Zenodo or a similar tool (DOIs for persistence).

2.3 Interoperable Data

Interoperability is at the heart of the BALTFLOODS integration plan (see Deliverable D1.2). All datasets will be structured in **open, standards-based formats** to ensure machine-readability and compatibility with external systems. This means:

- **NGSI-LD** as the core information model for real-time data exchange, allowing all entities (sensors, events, citizen observations) to be described with consistent attributes.
- **OGC standards** where relevant: GeoTIFF for raster data (satellites, UAV imagery), GeoJSON or shapefiles for vector geospatial data, SensorThings API specifications for sensor metadata.
- **Time-series storage** in formats suitable for both human and machine access (e.g., JSON over API, CSV for bulk exports).
- **Metadata schemas** following Dublin Core and ISO 19115 where possible, ensuring cross-disciplinary discoverability.

Citizen-contributed data will also be structured in interoperable ways. For example, reports of local flooding will be represented as *IncidentReport* entities, compatible with FIWARE Smart Data Models. This ensures that citizen inputs can be integrated alongside sensor and satellite feeds without custom connectors.

By aligning with these standards, BALTFLOODS guarantees that its datasets are not locked into proprietary tools and can be integrated into municipal systems, national data portals, or reused in research without reformatting.

2.4 Reusable Data

Reusability ensures that BALTFLOODS data continues to generate value long after the project ends. To achieve this, all open datasets will include:

- **Clear licensing information**: By default, datasets will be released under **Creative Commons Attribution (CC-BY 4.0)**, unless otherwise specified. For citizen-contributed data, consent will be obtained to use and redistribute anonymised contributions under **CC0 (public domain)** where possible. Restricted datasets (e.g., sensitive municipal SCADA logs) will remain under municipal ownership and not be openly licensed.
- **Rich metadata**: Each dataset will include descriptions of methodology, data provenance, collection period, responsible partner, processing steps, and version history. This contextual information enables others to assess quality and reuse appropriately.
- **Alignment with international frameworks**: BALTFLOODS data models align with the **FIWARE Smart Data Models initiative**, EU INSPIRE principles, and Sustainable Development Goal (SDG) indicators where applicable. This ensures compatibility with ongoing European and global initiatives.
- **Quality documentation**: For scientific datasets (e.g., satellite or lab measurements), calibration methods, uncertainty ranges, and validation approaches will be documented. For citizen science data, validation protocols (e.g., tiered checks) will be clearly described to support confidence in reuse.

In practical terms, this means that another municipality in the Baltic Sea Region (or beyond) will be able to adopt BALTFLOODS datasets, tools, and methodologies as a blueprint for their own flood and stormwater management systems, without starting from scratch.

Towards flood resilient cities powered by data and people.

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