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Open Geospatial Consortium

IT GETS MUDDI – A QUEST FOR BETTER SUBSURFACE DATA (THE MUDDI FOR EVERYONE GUIDE)

USER GUIDE

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LIST OF FIGURES

I KEYWORDS

The following are keywords to be used by search engines and document catalogues.

ogcdoc, MUDDI, underground

II PREFACE

Our dear friend and colleague Geoff Zeiss contributed greatly to the community and to the work which led to the MUDDI model, but sadly passed away before we reached the milestone of publication. The OGC MUDDI Standards Working Group wishes to recognise and commemorate Geoff's contribution to this work.

III SECURITY CONSIDERATIONS

No security considerations have been made for this document.

IV SUBMITTING ORGANIZATIONS

The following organizations submitted this Document to the Open Geospatial Consortium (OGC):

- Ordance Survey
- GISMO
- BGS

V CONTRIBUTORS

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1 SUMMARY

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Data about sub-surface infrastructure is very relevant for the safe and efficient operation of our towns and cities, yet often difficult to access and therefore invisible. This guide explains how underground data can be structured so it can be easily accessed and understood not only by the producer of this data, but by all relevant parties in the Urban Environment including community members who want to understand what goes on beneath their neighborhoods.

MUDDI, the Model for Underground Data Definition and Integration is published by the Open Geospatial Consortium, an industry forum and standardization organization. We believe in making data Findable, Accessible, Interoperable and Re-usable. The MUDDI Conceptual Model is an open international standard and defines a data structure or data model for sub-surface information. It is free to use by everyone and empowers communities who want to benefit from better managing their hidden underground infrastructure.

This guide describes what a data model is, how it is applied and what benefits can be expected.

2

THE BASICS OF A DATA MODEL — YOUR FAMILY TREE

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The best way of approaching an understanding of data models for underground infrastructure is to examine an instance of organized data that everyone is familiar with: The Family Tree contains many of the elements we find in data models whose purpose is to identify and organize objects and processes in the physical world. The key features of a family tree are the names of relatives arranged by links within and across generations including the connections between parents, children, aunts, uncles, cousins, nephews and nieces. It can also detail other characteristics (or attributes) such as dates of birth and death, and may additionally show where family members came from. If all this information were not arranged in a tree-like format, but instead was put into a long listing, it would be very difficult to understand all the different family branches and their relationships to each other.

The key thing is that, like a Family Tree, a Data Model represents concepts, objects and relationships that exist in the real world. Examples might include representations of things like planning zones and streets or buildings, and how these concepts and objects relate to each other — spatially or otherwise. In this way, when data is structured in a way that is defined by that Data Model, we can be more confident that data more accurately describes the real world features it is meant to represent.

If the family trees of several families are drawn in the same way, we can more easily work with data from different sources, compare and perhaps integrate them into an overarching tree covering different branches of a family.

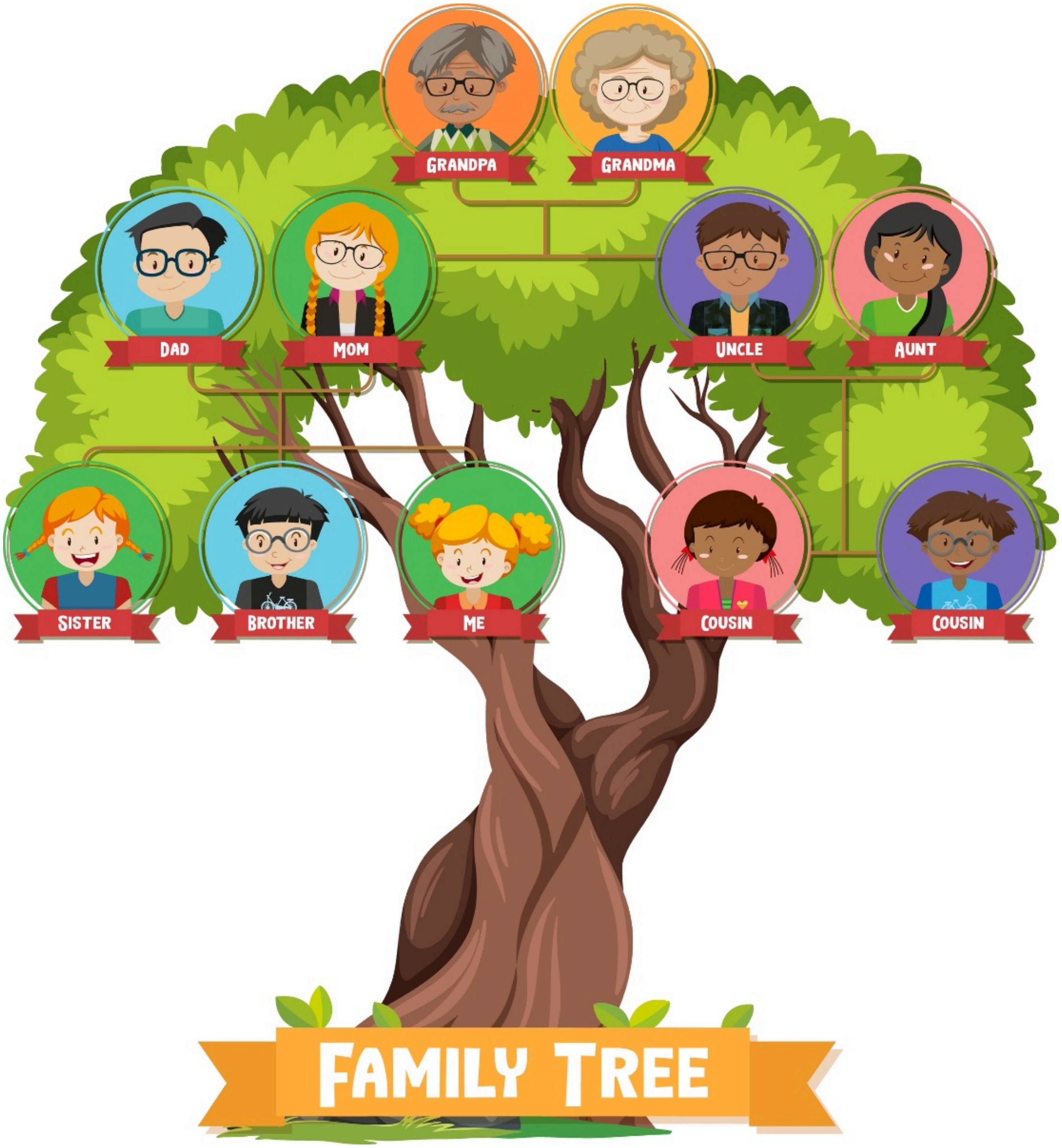

Figure 1 — A family tree © Sketched Images/Shutterstock.com

3

WHY DATA MODELS ARE IMPORTANT

3 WHY DATA MODELS ARE IMPORTANT

Just as a Family Tree organizes members of an extended family in a standardized way so that they are more easily understood, a data model organizes information pertaining to the real world in a way that makes it more easily grasped, enabling the information to be incorporated into computer applications that allow the data to be collected, stored, updated, expanded, combined, visualized and analyzed in useful ways. When a data model pertaining to parts of the real world (domains) are "standardized" and used in the same form across a jurisdiction, state, or nation it then becomes possible to easily combine the data across borders for larger scale and more economical operational and analytic tasks. Data stored in these systems becomes interoperable and creates additional value for the community.

Data models exist for buildings, roadway systems, manufacturing processes, medical services, logistics, and are used for many other purposes, all of which can be described by a logical assembly of features and their characteristics (attributes) to be organized in hierarchies and by function.

4

A DATA MODEL FOR UNDERGROUND INFRASTRUCTURE

4 A DATA MODEL FOR UNDERGROUND INFRASTRUCTURE

Starting in 2017, the Open Geospatial Consortium identified underground utilities and other underground features as a domain (subject area) where existing data was largely disorganized, unknown, or held in many different formats, that it was impossible to make sense about what was there.

This situation is exemplified by the mapping response to the attack on the World Trade Center (WTC) on September 11, 2001. It took responders more than ten days to collect and piece together utility, structural, and geological information for the acres of collapsed area beneath the World Trade Center to support rescue and recovery operations.

Of course, the biggest obstacle to assembling underground data is that almost all features are buried and therefore invisible: we really don't know where they really are after they are installed and covered up, and this creates a myriad of problems. Below you will find an image of a road network in the Inwood neighborhood of Manhattan which pictures a variety of roadway types including: highways, main avenues, two-way streets, one-way side streets, and walkways. There will be a significant amount of underground infrastructure in the areas shown on the map–it is just not included in the data model of this map and is therefore invisible.

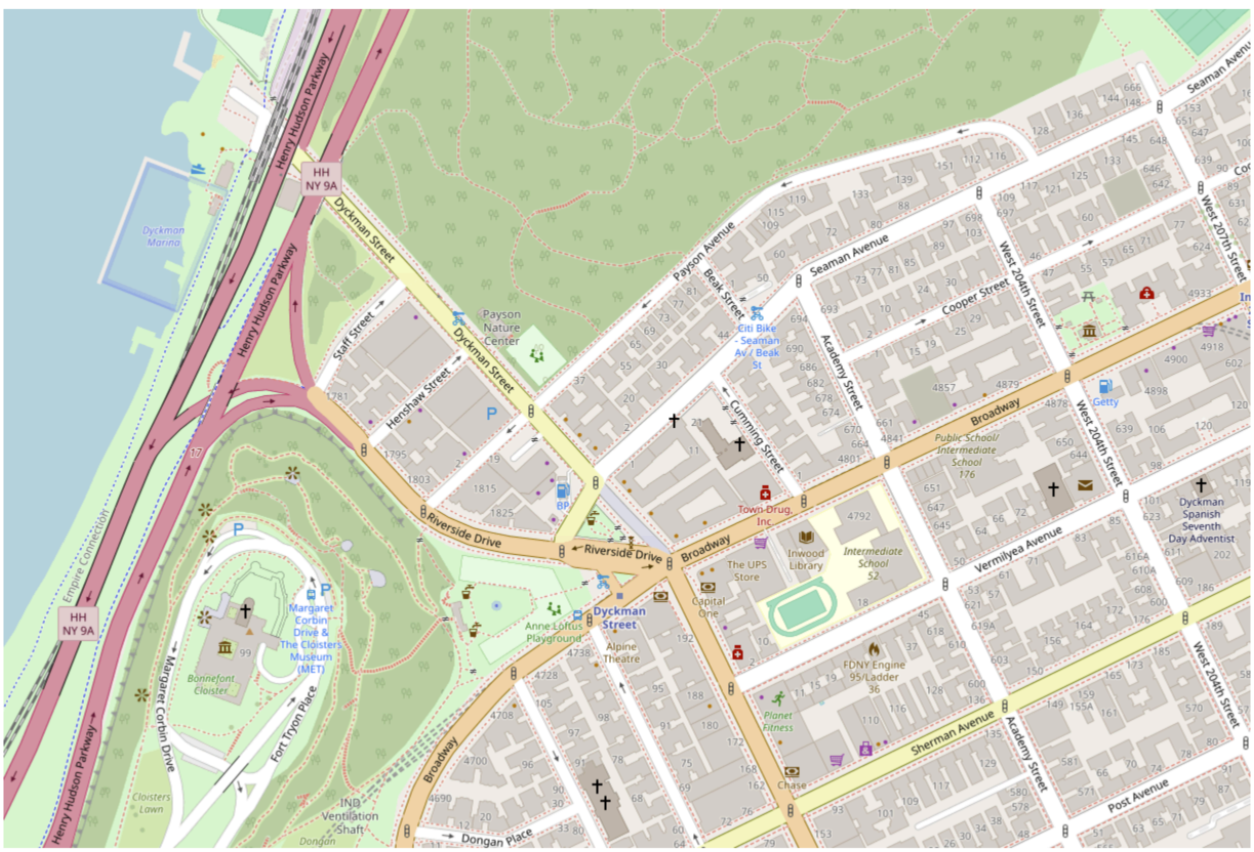

Figure 2 — A portion of Inwood, Manhattan © OpenStreetMap contributors

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BASIC COMPONENTS OF AN UNDERGROUND DATA MODEL

5 BASIC COMPONENTS OF AN UNDERGROUND DATA MODEL

Just like the names in a family tree, and the different kinds of streets in a road network, the basic features of an Underground Data Model are those elements that actually carry or conduct the utility service itself, such as water, sewerage, electricity, gas, steam, and communications signals. These transporting features that make direct physical contact with and direct the service flow, are known as "conveyance" assets and they are sections of pipe and cable that are connected together to form a utility network that can cover entire cities or regions, linking utility sources like reservoirs with connections into buildings.

But like a family tree, there are many other parts of a data model than just a basic family unit of husband, wife, and children. In the case of underground infrastructure additional features associated with conveyance features include those that

- provide access to the conveyance network,
- provide physical support to the network,
- protect the network, and
- monitor the network.

Extending this idea even further, we can also append to a more complex underground model additional features such as building basements, building foundations, storage tanks and sidewalk vaults, abandoned features, and remnants such as abandoned trolley tracks, which can play important roles in understanding the underground environment.

Additionally, geological and environmental characteristics can be important to the nature of the underground, including soil type, bedrock characteristics, culverted or "lost" rivers, groundwater, and rock faults which might cause an earthquake. A cast iron water pipe embedded in bedrock will age differently from one running through moist, acidic, sandy soil. This way, we expand the model to understand and represent everything in the underground that is important to us.

6

THE IMPORTANCE OF UNDERGROUND LOCATION

6 THE IMPORTANCE OF UNDERGROUND LOCATION

The reason why the Open Geospatial Consortium (OGC) took on the job of developing MUDDI as an underground utility data model is because OGC has a particular focus on the location characteristics of real-world features. While location is often important, obtaining location information for underground assets is crucial because they cannot be seen by the naked eye or easily sensed. Sub-surface data is often disorganized, incomplete, incompatible and stored in inaccessible silos. Most typically, if you need to dig a hole in a street, for example to repair or replace utility plant, you could accidently strike and break another utility pipe or sever a cable you did not know was there. For underground features it is important to identify accurately their position in the world, as (x, y) coordinates or latitude and longitude, and their depth.

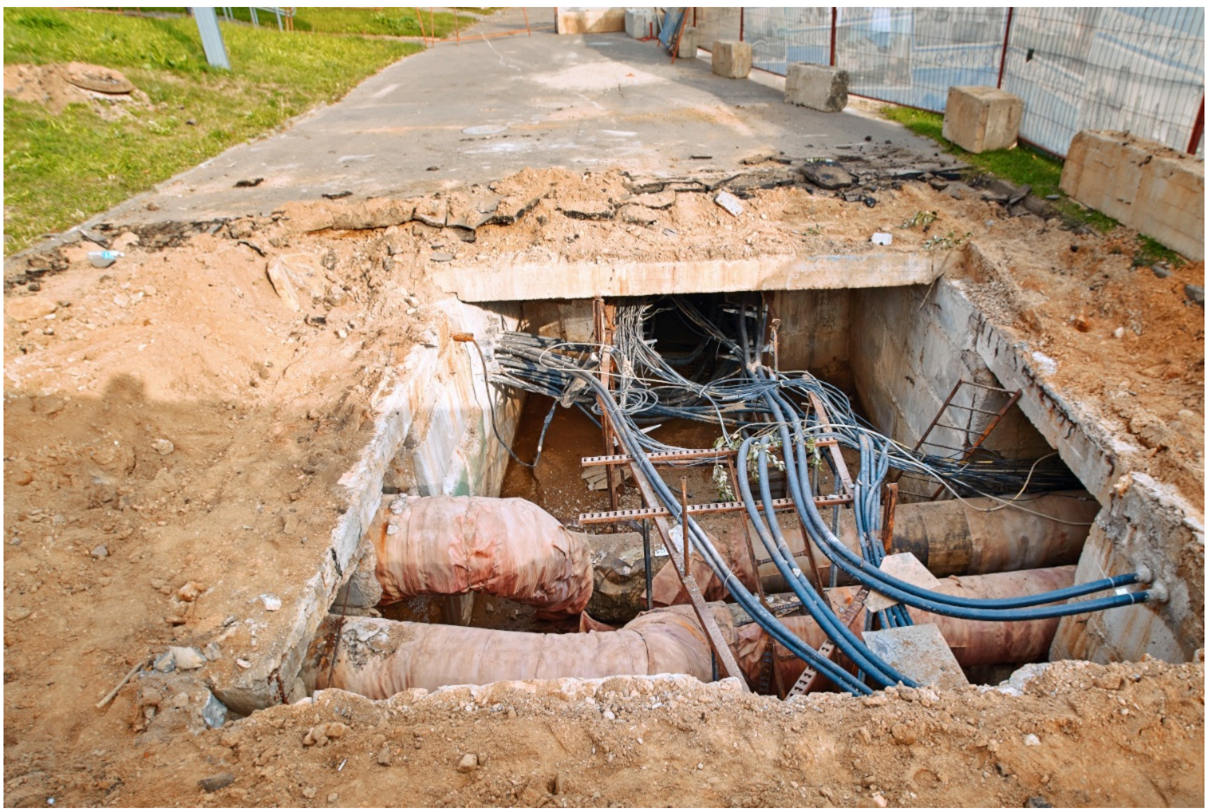

Figure 3 — A typical maze of utility infrastructure © Tricky_Shark/Shutterstock.com

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HOW ORGANIZED AND STANDARDIZED UNDERGROUND DATA CAN BE USED

7 HOW ORGANIZED AND STANDARDIZED UNDERGROUND DATA CAN BE USED

The development of an underground utility data model is more than simply a good idea. Knowing where underground features are located saves money, improves services, and saves lives. The need to access data from different organizations and to share data between different entities is common. The following are operational areas where having standardized, comprehensive, and accurate underground information is vital.

- Excavations: Utility companies and public work agencies are constantly digging into streets to replace, repair, or upgrade underground utilities. In large cities like NYC and London, more than 150,000 such excavations take place annually, with hundreds of accidental strikes that result in great expense, utility outages, and in some cases, loss of life – when a powerful electric line is struck, or when a gas pipeline or steam pipe explodes. Having good utility information is the foundation to reduce these incidents, as can be seen in this example.

- Major Capital Projects: As urban areas change and age it is critical that underground utilities are replaced, renewed, or upgraded to accommodate growing populations and expanding needs. These projects can cost millions and even hundreds of millions of dollars. If the underground excavation work to build these projects encounters unexpected underground features, these initiatives can be delayed for months and years, and cost millions more than estimated. Knowing the structures that already exist underground is key to expediting and reducing the cost of capital programs. ROI studies have proved that investment in underground utility data pays for itself when compared to the cost of building and maintaining underground data.

- Planning: In order to properly plan for the future of any jurisdiction, it is essential to know what is there now both above ground and below ground. Underground utility information gives planners the information they need to make the best possible decisions about how an area is to develop in the most efficient way. Project Iceberg summarized the planning benefits for underground data.

- Energy Transition: One more detailed example for planning would be connecting new low or zero carbon technologies to the electricity grid. This would include electric vehicle charging points, heat pumps, solar panels and batteries. As utility networks are capacity constrained in certain areas, both the location of the network as well as the capacity of the network in a local area need to be known for effective planning. An example is the development of an Energy System Map.

- Utility network management: Properly managing and maintaining underground assets during the entire lifecycle of underground features is important to maintaining utility services and ensuring that network failures and breakage is minimized. By having detailed data of utility feature age, capacity, and material and by designing and carrying out effective maintenance operations, utility services become more reliable and cost effective, lowering consumer prices and reducing outages. This article provides a good overview.

- Digital Twins and Artificial Intelligence: With the increasing availability of new sensor technology and the advent of artificial intelligence, new tools are being made available to increase the power of location (or spatial) applications. Sensor location is key to any information that these devices collect. Also, artificial intelligence applications depend on enormous volumes of information to search, select, and turn into useful products. The ability of spatial data to be integrated based on their common location fields allows artificial intelligence systems to “train on” extraordinary amounts of spatially standardized and related information.

- Environmental Interactions with Underground Infrastructure: Buried infrastructure features are subject to a variety of costly environmental impacts caused by high surface temperatures, flooding, erosion, earthquakes, and corrosion. It is important to understand how these conditions affect built underground features in order to improve mitigation and protective measures, and as an aid to future planning and design. For example: MUDDI data is essential to our ability to better understand how surface water can invade basements and tunnel structures; and how moisture, salt water, and harsh chemicals can weaken and age pipes and conduit.

- Emergencies and Disasters: Weather events such as violent storms, flooding, drought, and extreme heat can have significant impacts on underground infrastructure. So can geological events such as landslides and earthquakes. Additionally, events caused by human negligence or malignancy can also – as in the case of the WTC attack – cause immense destruction to infrastructure critical to societal operations. These events, in addition to costing billions of dollars in infrastructure damage, can also result in loss of life. Knowing where critical underground assets are located, and understanding their vulnerabilities, gives emergency and disaster planners the opportunity to take preventive actions that can limit the destruction caused by these events. For example, Hurricane Sandy caused tens of billions of dollars of damage to New York City infrastructure. However, post disaster assessments have found that low-cost protective measures on critical infrastructure such as protective walls around low lying electric substations, and making sure important buildings, like hospitals, had been water tight, could have potentially reduced this cost by billions.

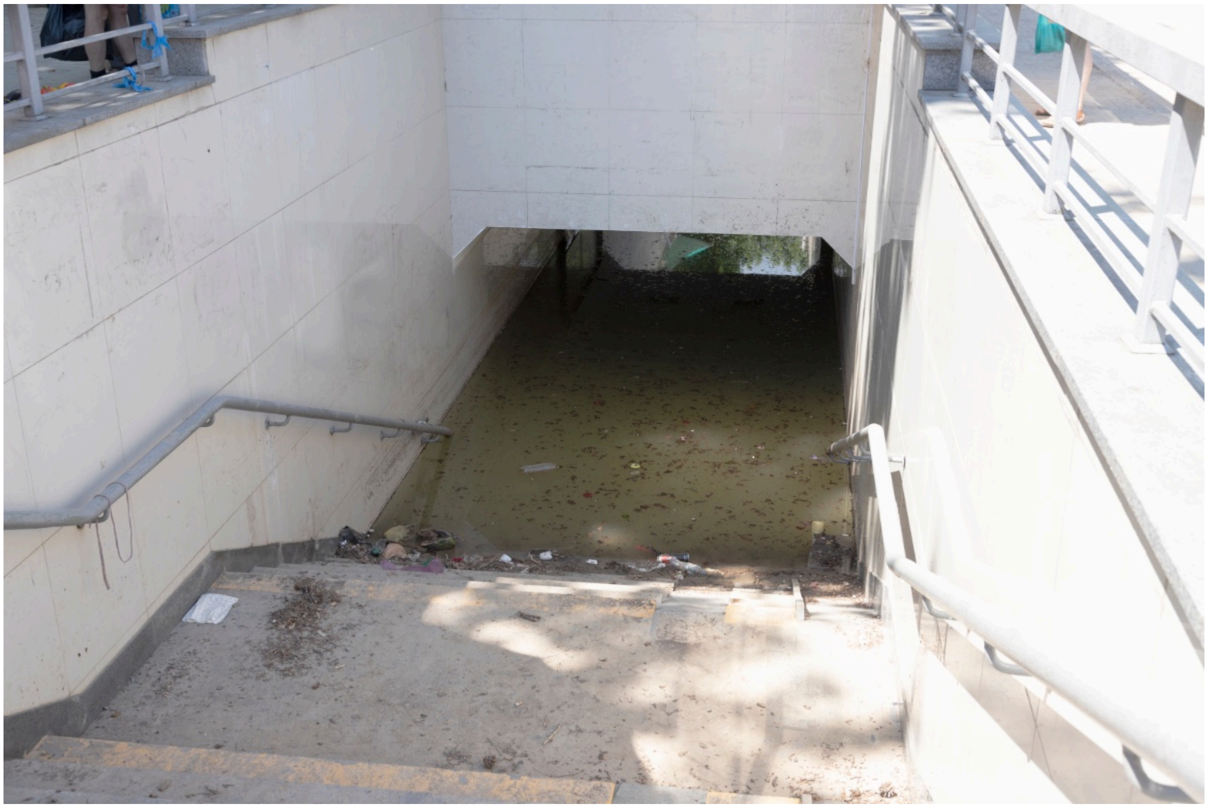

Figure 4 — Flooding of a subway entrance © Vadi Fuoco/Shutterstock.com

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HOW TO WORK WITH MUDDI

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MUDDI can be implemented by any organization independently of the technology platform or software they are currently using. The most visible and comprehensive example of implementing a MUDDI compliant data model is the National Underground Asset Register (NUAR) in the United Kingdom. Data from more than 200 owners of underground assets in the UK is available in a UK-specific implementation of MUDDI, targeted to the needs of the UK safe-dig community.

9

CONCLUSION

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We hope we have shown the importance of creating comprehensive and accurate underground data, that is well organized (by a standardized data model), and includes precision location information, to support a variety of vital operations. An underground data model is not going to solve all sub-surface issues but is the most fundamental step to create a shared understanding of the underground between different stakeholders and for different use cases.

While the art of data modeling can seem quite daunting and can be technically complex, the concepts behind it are easy to understand. Basically, a jurisdiction must know the location and characteristics of its most important built and natural features in order to mitigate the risks of inefficiencies, catastrophic damage, and unnecessary loss of life.

The 'MUDDI for everyone guide' was created by the MUDDI Standards Working Group at the OGC and can be contacted by email.