

In Relief The City Of Lausanne



An Urban and Subterranean Analysis of a City on a Slope

Up
In Relief
The City of Lausanne
Down

 2025, Julien Genin

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Image: Saint-Laurent hill
Collection L. Polla, c. 1902.



Image: Saint-Laurent hill
L. Polla, c. 1984.

ABSTRACT

The city of Lausanne, situated on a landscape shaped by steep slopes, hills, moraines, and valleys, stands as a remarkable example of urbanization influenced by natural constraints and geographical opportunities. This thesis explores how Lausanne's unique topography has shaped its urban development, infrastructure, and underground networks, while examining the interplay between surface and sub-surface elements. Understanding what lies beneath and above its terrain is critical to addressing future construction challenges and optimizing the connection between these layers, taking full advantage of the benefits offered by a sloping city.

Amid large-scale projects such as the expansion of Lausanne's railway station to accommodate growing traffic, the renovation of the Riponne parking structure to address water-proofing and capacity issues, and the development of the future metro line linking the station to Blécherette, this research focuses on the historical evolution of Lausanne. It investigates how the city adapted its natural terrain to meet growing infrastructure demands, transforming constraints into drivers of innovation. The central question revolves around how Lausanne has evolved on its terrain, making use of its soil and subsoil.

The methodology combines historical, geographical, and technical approaches. The study involves the analysis of urban plans, historical documents, and technical reports, alongside interviews with local experts such as water management authorities, representatives of CFF railway infrastructure, and specialists in underground networks. These insights are complemented by personal observations and case studies of key sites such as the railway station, Riponne Square, and the Flon district.

Findings reveal that Lausanne's relief, shaped by the retreat of the Rhône glacier, presented significant challenges while offering unique opportunities. The city's need to redirect rivers like the Louve and the Flon, and to connect its hills through bridges, tunnels, and multi-level structures, showcases its ingenuity in adapting to its terrain. Recent innovations, such as the M2 metro, the LEB train line, and the Tridel tunnel, highlight Lausanne's ability to integrate modern solutions within a historically and naturally complex environment.

This research emphasizes the vital role of Lausanne's underground networks in managing topographical constraints and urban needs. The Louve and Flon rivers, now channeled underground, coexist with modern infrastructure such as metro lines, service tunnels, and railway networks. These interconnected layers between the surface and subsoil demonstrate how the city has optimized every aspect of its space to meet social, economic, and environmental demands.

In conclusion, this thesis highlights how Lausanne has transformed its terrain not only as a challenge to overcome but as a resource to harness. It provides insights into the evolution of public spaces, such as Riponne Square and the railway station area, where current issues of congestion and livability must be addressed with consideration of the city's history, existing networks, and future innovations. These reflections pave the way for better integration of the underground into future development, strengthening the links between surface and sub-surface spaces, and maximizing the benefits of a sloping city.



Image: Flon valley before infilling
Musée de l'Ancien Evêché, c. 1905.



Image: Flon valley and its
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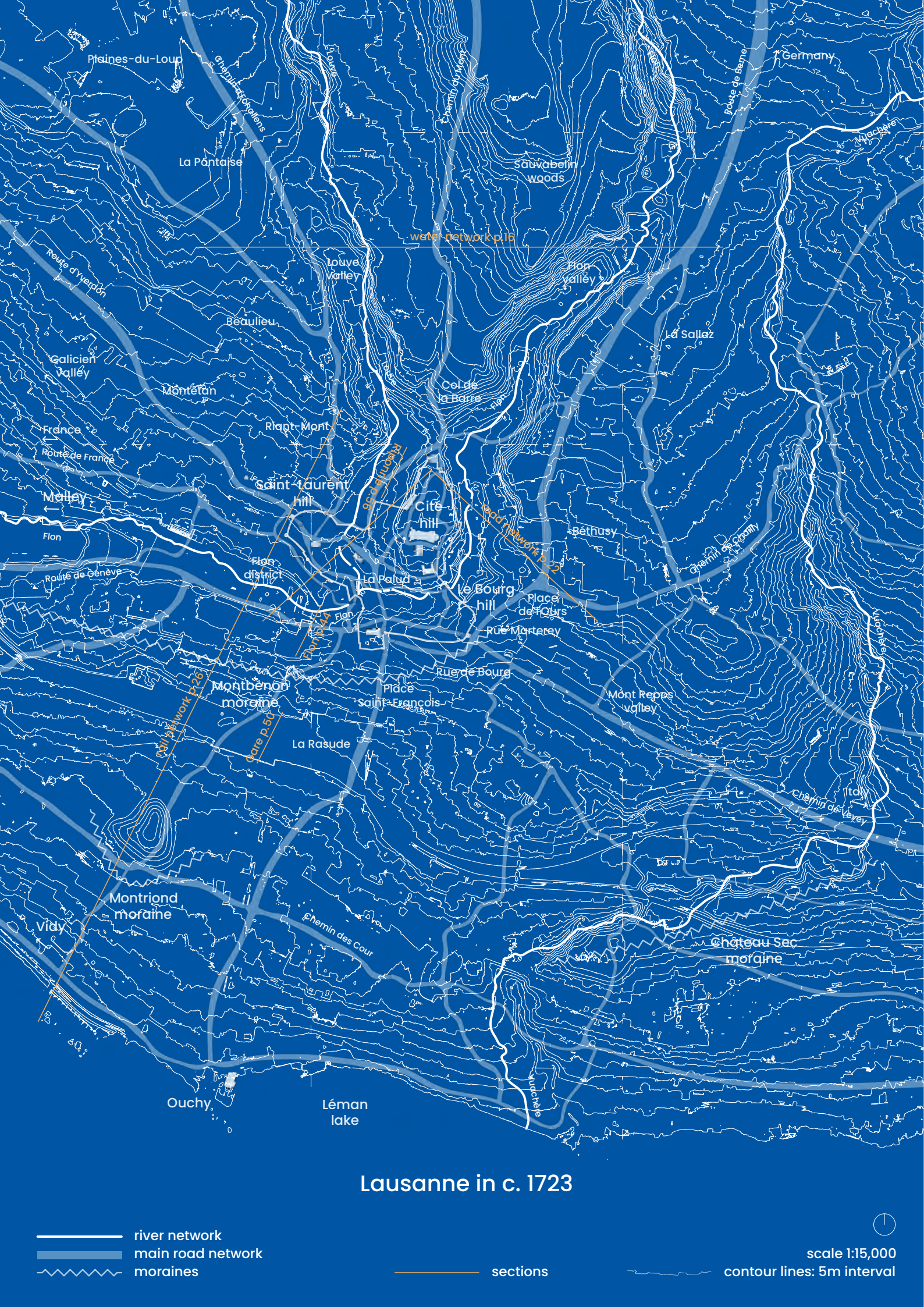
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Musée de l'Elysée, c. 1890.



Image: View of the Cité hill
L. Polla, c. 1984.

INTRODUCTION

The city of Lausanne, nestled between Léman lake and shaped by the Alpine landscape, is defined by its distinctive topography of hills, moraines, and valleys. Unlike cities built on flat terrain, Lausanne's sloping geography has profoundly influenced its urban development, shaping its infrastructure, architecture, and social fabric. Understanding how this terrain was formed, how it has been transformed, and what lies beneath and above it is essential for tackling modern urban challenges and ensuring that future construction leverages the benefits of a hilly cityscape. Lausanne's ability to balance its natural constraints with innovative solutions offers a fascinating case study in urban resilience and ingenuity.

This thesis is set against the backdrop of key contemporary challenges in Lausanne's urban planning, including the expansion of the main railway station - a project complicated by its location on a slope - and the introduction of a new underground metro line connecting the railway station to the Blécherette highlight the increasing demand for sustainable and efficient transportation in a constrained and densely populated urban environment. These projects underscore the importance of understanding Lausanne's unique topography and its sub-surface networks to better integrate and optimize both levels of the city.

Historically, Lausanne has had to adapt its urban design to its steep terrain. The Flon and Louve rivers, which once shaped the city's valleys, have been channeled underground, transforming their spaces into vital arteries for transportation and commerce. This redirection has allowed for the construction of bridges, roads, and buildings that connect the city's hills, facilitating urban expansion while preserving the unique character of its relief. Yet, these interventions also pose challenges: congestion at key sites like the

railway station, limited open space in the city center, and the social isolation of some areas, such as Riponne Square, highlight the tensions between Lausanne’s historical legacy and its modern needs.

The central question driving this research is how Lausanne has evolved on its terrain, using its natural topography and subsoil as tools to overcome constraints and create opportunities. This thesis explores the historical, geographical, and technical factors that have shaped Lausanne’s urban development. The objectives are to understand the formation of Lausanne’s relief, analyze its interaction with underground networks, and identify the constraints and advantages that have emerged from this interplay. Specifically, the research highlights how Lausanne has turned its steep terrain into an asset, providing opportunities for multi-level accessibility, natural light, panoramic views, and creative land use strategies.

To achieve these goals, the methodology combines historical research, technical analysis, and field studies. With images by L. Polla, from his book “Lausanne Passé et Présent sous le même angle”, accompanying the text throughout. Historical maps, urban plans, and technical reports are examined to trace Lausanne’s evolution over centuries. Case studies focus on key sites such as the Flon district, the railway station, and Riponne Square, illustrating the city’s approaches to overcoming topographical challenges. Interviews with local experts - engineers, architects, and urban planners - provide valuable insights into the technical and logistical strategies behind Lausanne’s urban planning. Direct engagement with the sites enrich the analysis with a practical understanding of their design and function.

The thesis is structured in two main parts. The first explores the formation and transformation of Lausanne’s relief, beginning with the retreat of the Rhône glacier, which shaped its moraines and valleys. It examines the historical role of the Flon and Louve rivers in defining urban growth and how their redirection underground enabled the development of bridges, roads, and tunnels to connect the city’s fragmented hills. This section also analyzes the evolution of the railway and metro networks, which have navigated the constraints of the hilly terrain to enhance mobility and connectivity.

The second part focuses on contemporary strategies for building on slopes, examining the opportunities and constraints presented by Lausanne’s topography. It delves into the design principles and technical challenges of key projects, such as the Flon district’s multi-level infrastructure, the railway station’s expansion, and Riponne Square’s redevelopment. These cases highlight how Lausanne’s topography has been both a challenge to overcome and a resource to harness, demonstrating innovative approaches to urban planning and sustainability.



Image: Infilling of the Flon valley
Musée historique de Lausanne
c. 1905.

This thesis reveals that Lausanne’s relief is not merely a constraint to be managed but a defining feature of the city’s identity and an opportunity for creative urban solutions. It underscores the need to better connect the city’s surface and sub-surface networks, ensuring that each layer complements the other to create a cohesive and functional urban environment. By understanding Lausanne’s historical evolution, its hidden underground systems, and its innovative use of topography, this research provides valuable insights into how cities with similar geographical challenges can turn their natural constraints into powerful assets for sustainable growth.



Image: Green slopes of the Flon valley, Musée de l'Elysée, c. 1870.

FORMATION OF THE RELIEF

Towns settle on the land according to characteristics necessary for their development. Land is formed in different ways. Lausanne's complex topography of hills, valleys and waterways has had a profound influence on its urban development and history. This geographical peculiarity determined not only the location of the first human settlements, but also the major stages of urbanization, the construction techniques employed and the challenges faced by the people of Lausanne in building their city.

The city rests on a soil composed of successive geological layers, the result of natural and man-made processes. Alluvium, glacial muds and moraines left behind by the retreating Rhône Glacier, combined with deposits accumulated by human activity, tell the story of a thousand years of history. These superimposed layers bear witness to the different periods that have marked Lausanne. Archaeological digs reveal remains that, when analyzed, provide a better understanding of the city's evolution, from the earliest human settlements to the present day.

From Roman times, Lausanne, then called Lousonna, developed at Vidy, on the shores of Léman lake. This site, chosen for its proximity to the waterway, offered advantages for trade, but its exposure to invasions made it vulnerable. This led people to migrate to the more defensive hills, where the old town on the Cité hill now stands. This change in location marked a turning point in Lausanne's history. The move to the heights not only redefined urban organization, but also imposed constraints linked to the slope and fragmentation of the territory by the Flon and Louve valleys.¹

¹ L. Flutsch, "Passé Présent : "Lousonna" ou l'Antiquité d'Actualité".

Image: Flon district
L. Polla, c. 1984.

Set against a slope that drops from 901 to 373 m, Lausanne is both a city on a slope and a gullied city. Its territory is marked by more or

less deep valleys that delimit interfluves of various shapes: simply outlined slopes or vigorous spurs. Between the Flon and Louve rivers, below the Sauvabelin wooded ridge, lie the Cité spur, crowned by the cathedral and separated by the narrowing Col de la Barre to the north of Château Saint-Maire. Further south, between the Flon and Vuachère rivers, the interfluve blossoms at Béthusy, dominating the Mon Repos valley. Another plateau rises rapidly from Saint-Laurent to Riant-Mont, Beaulieu and La Pontaise, towards the Plaines du Loup, framed by the valleys of the Louve and Galicien towards Montétan.

The city center, the Flon district is about 2 km from the shore of Léman lake and lays at around 480 m higher compared to the 373 m high lake. The Flon valley, between La Sallaz and Sauvabelin, plunges to a depth of 60 m. The Louve valley, between Sauvabelin and les Plaines du Loup drops 30 m. The lateral Montbenon moraine is considerable, with differences in height ranging from 25 to 40 m in relation to the Flon bed. The town, once built on three hills, has evolved into a hillside settlement, with a spread until the lakeshore as the lake besing the only hard boundary for urbanization.

The meeting of these valleys and interfluves creates geographical bottlenecks that are key points for Lausanne traffic, such as Place de l’Ours and Place Saint-François. Here, the Montbenon moraine is criss-crossed by a double gully, caused by the confluence of the Flon and Louve rivers to the north, and by the gullies leading to the lake to the south. To the south of Saint-François and Montbenon, a series of gutters runs straight down to the lake, on either side of the Montriond butte, which could be a morainic witness, a fluvio-glacial pile deposited in a temporary lake.

Lausanne’s relief is the result of an interaction between powerful natural forces, notably the action of glaciers, and human transformations. As seen in the diagram on the next page, the advancing and retreating the Rhône Glacier has sculpted the landscape, creating lateral moraine and hills such as Montbenon and Montriond moraine and the three hills Cité, Le Bourg and Saint-Laurent where the city is built on. These formations have posed challenges for the construction and expansion of the city. The slopes are made up of morainic clay, an unstable soil that is liable to slide. Specific measures must be taken in this respect, for example during major works such as the construction of the railway station in the 19th century, which endangered an entire neighborhood.²

As Lausanne is located at the foot of the Alps, the city’s soil is mainly composed of mollassic soils and its own sediments. Mollassic soils are derived from sedimentary rock layers formed by deposits of sand and clay. They retain moisture but can become heavy and compacted when wet, and therefore need good drainage. The steep slopes of Lausanne, combined with rainfall, may make the mollassic soils

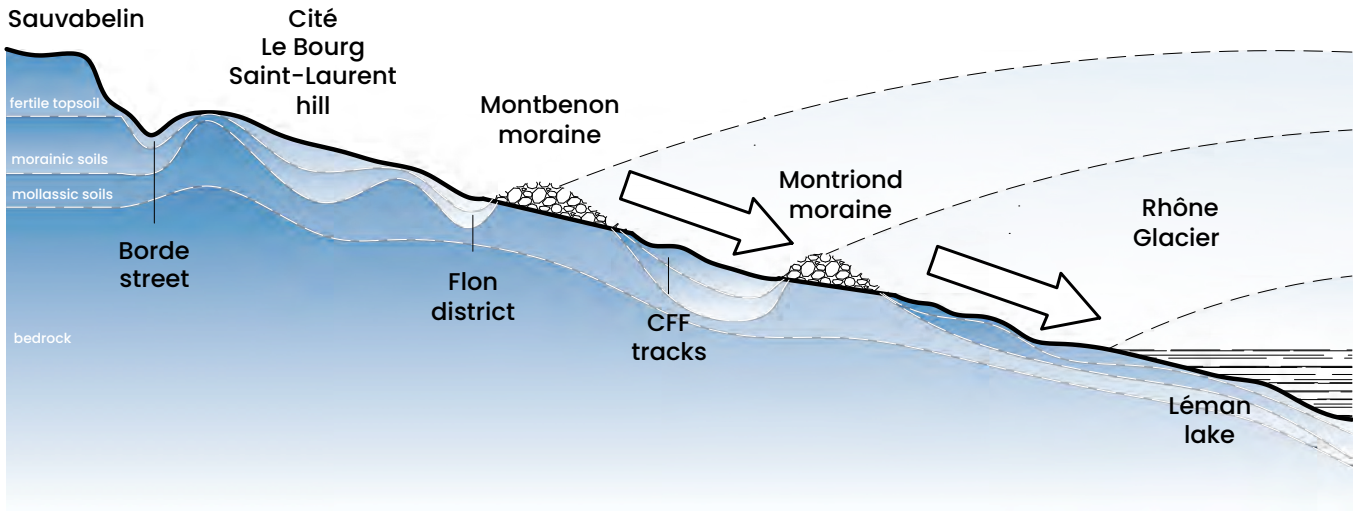


Diagram: Formation of Lausanne’s topography.

prone to erosion. Steeper areas may have thinner, less stable soils due to erosion, while flatter areas may accumulate deeper, more fertile layers. This terrain was later covered by layers of superficial moraine and glacial mud. The morainic soils pose then challenges for construction, such as the need for soil reinforcement in certain areas.

Urban planning must account for water retention and potential waterlogging, but the fertile nature of the soil makes it ideal for vineyards and gardens, which are a feature of Lausanne’s landscape. Mollassic terrain extends as far as the lake, but between the Léman lake and the northern foot of the Montbenon moraine, it is no longer visible on the surface.

The two main rivers, the Flon and the Louve, have also played a structuring role. Originally, these rivers flowed in the open, shaping the valleys that separate Lausanne’s neighborhoods. In the past, they flowed directly towards the lake after meeting in a valley that no longer exists, roughly following the present-day trajectory of the Lausanne-Ouchy railroad line.³

Valleys and interfluves do not always follow the line of the steepest slope. The Flon, for example, bends at right angles due to complex moraine obstacles which made a new invasion into the Léman lake, depositing a lateral moraine that formed the elongated Montbenon moraine. These ridges forced the two rivers to divert momentarily to the west and become entrenched, thus creating topographical accidents perpendicular to the generators of the terrain. These detours are visible via the narrow natural causeway of Rue Marterey and Rue de Bourg, which lead to Saint-François and Montbenon. The course of the Flon was then blocked, forcing the water to flow

² L. Grivel, « Historique de la Construction à Lausanne ».

³ H. Onde, « La Pression du Relief sur l’Urbanisme Lausannois ».

along this moraine, before heading towards Malley and resuming its descent towards the lake. Not only did they serve as a resource for mills and other craft activities, they also acted as natural barriers, forcing the construction of bridges to link the different parts of the city. In the 19th century, vaulting works buried these rivers, transforming the valleys into traffic arteries and paving the way for more fluid urbanization.³

Historically, Lausanne’s rugged terrain has guided its tiered organization, centered around the three large hills. La Cité, with its cathedral and castle, quickly became the city’s political and religious heart. Its strategic position on a natural promontory offered a natural defense against invasions, but also presented a challenge for communication with the other districts. The market towns of Saint-Laurent and Le Bourg, located on neighboring hills, emerged as commercial and artisanal hubs, supported by the international routes that crossed Lausanne.⁴

The medieval city walls, built over the centuries and intact until the 18th century, reflect the city’s adaptation to its topography. Initially limited to the Cité, they gradually encompassed the districts of La Palud, Saint-Laurent and Le Bourg, reaching their maximum extension in the 14th century. This expansion linked the various hills, but also highlighted the difficulties of urbanizing a rugged terrain. The city’s natural setting on multiple hills made construction and connectivity challenging. Building walls and roads required navigating steep slopes and uneven ground, increasing labor and costs.

Linking the districts required bridges or reinforced pathways to cross valleys or ravines between the hills. In rugged terrain, streets were often constrained by the topography, leading to narrow, winding pathways rather than straight, wide roads. The winding streets and sloping passageways characteristic of the historic center still bear witness to these challenges today. The streets and passageways connect the historic districts, such as the Cité, La Palud, Saint-Laurent, and Le Bourg, which were originally isolated on separate hills. These connections required careful planning to bridge valleys and navigate elevation changes. The width of many streets reflects the constraints of building in a confined, irregular space. Wider, straighter streets would have required significant restructuring of the terrain, which was impractical in medieval times. Small squares and terraces in the historic center, like Place de la Palud, are irregularly shaped, created by making use of whatever flat spaces were naturally available or could be carved into the hills.

The 19th century marked a period of major transformation for Lausanne. Economic and demographic growth, coupled with industrialization, led to ambitious development projects to overcome the constraints of the terrain. The Flon valley, once an obstacle,

⁴ J.-C. Biaudet, “Histoire de Lausanne”.



Image: Confluence of the Louve and the Flon, Laurent Wavre, 2015.

was filled in, as seen in the two comparative images (p.15), the area has been transformed into flat land, allowing for construction. Soil, rubble, and debris from construction and excavation projects in other parts of the city, were transported to the Flon Valley, for example from the boring of the tunnel for the Lausanne-Ouchy funicular. Quarry materials like stone and gravel were added for structural support and stability. The valley was filled in layers to ensure stability and allow for compaction over time. This process minimized the risk of subsidence in the newly leveled areas. This project symbolized the city’s desire to modernize, integrating its various districts and facilitating traffic flow. Other works, such as the construction of the railway station and the development of tramway lines, reinforced this dynamic.

At the same time, the vaulting of the Flon and Louve rivers freed up space for new construction. These rivers, once sources of life and craft activities, have become underground infrastructures, testifying to Lausanne’s ability to transform its natural constraints into opportunities. As seen in the image, the two rivers are now controlled in terms of both their flow and water quality. The creation of a network of bridges and tunnels also made it possible to overcome steep slopes and connect isolated neighborhoods, marking a decisive step in the unification of the city. In the 20th century, Lausanne continued to expand, while seeking to preserve its historical heritage. Development projects on the Flon plateau, transformed into a dynamic cultural district, illustrate this desire to combine modernity and tradition.⁵

As Lausanne industrialized and its population expanded, the Flon Valley became a hub for warehouses, workshops, and transport infrastructure. The heavy use of the Flon River for waste disposal

⁵ F. Studer, “Lausanne, Cité entre Flon et Louve”.

and industrial purposes led to significant pollution, creating health and environmental issues in the valley. The polluted state of the river and the unattractiveness of the industrial landscape pushed the city to reconsider the area's use in the late 19th century. Today, the city is striving to meet the challenges posed by its topography, particularly in terms of mobility and sustainable development, while at the same time making the most of its exceptional natural setting.⁵

Lausanne's topography, far from being a mere backdrop, is a key player in its development. It has shaped its history, dictated its urban planning choices and influenced its identity. Each hill, each valley, each waterway tells part of the story of this city, nestled between lake and mountains, and bears witness to Lausanne's ability to transform constraints into assets. This relief, which once held back the city's expansion, is today a source of pride and a central element of its charm and uniqueness. We understand that this relief was formed by the water springs that carved out the land. It thus constitutes the first main network influencing the town's development.



Image: Intersection of the Flon and the Louve, Musée de l'Ancien Evêché, c. 1867.



⁶ J.-C. Biaudet, "Histoire de Lausanne".

Image: The Centrale street
L. Polla, c. 1984.

WATER NETWORK

Lausanne's water network illustrates the ingenuity required to overcome the challenges of a city built on a complex terrain. From the management of open streams to the modernization of running water infrastructures, the development of this network reflects the city's historical, urban and technical transformations. Due to its rugged topography, Lausanne has had to adapt to ensure a reliable water supply, efficiently evacuate rainwater and control the streams that cross its territory.

In the Middle Ages, while the Flon and Louve Rivers' flow were not as strong as some alpine rivers, it was likely used to power small-scale mills and workshops, especially in earlier periods of pre-industrial activity. This was common in urban valleys where streams provided a consistent source of energy. The presence of the river supported various artisanal and industrial activities, such as tanneries, textile processing, and grain mills. These industries depended on water for processes like dyeing, washing, and mechanical operations.⁶

Their presence shaped urbanization by attracting workshops and artisans to settle along their banks, creating hubs of economic activity that influenced the layout and growth of the city. However, they also presented challenges, particularly during floods, which regularly damaged wooden bridges. Moreover, the river acted as a natural drainage system, carrying away industrial and domestic waste. While this solved immediate waste disposal needs, it contributed to the pollution of the river and the surrounding area, which eventually became a concern as the city grew.

To remedy these problems, as early as the 18th century, the city undertook the construction of more resistant arched stone bridges. Once the bridges were in place, the spaces beneath and around

them were often filled with earth, rubble, and construction debris. This infill acted to stabilize the area and effectively level the terrain on either side of the bridge. By adding this infill and extending it outward, the city effectively “buried” parts of the ravine under a new, flattened surface. This newly created ground was then used to establish public squares, as was the case with Place Pépinet, or building sites, transforming formerly inaccessible or underutilized areas into functional urban spaces.

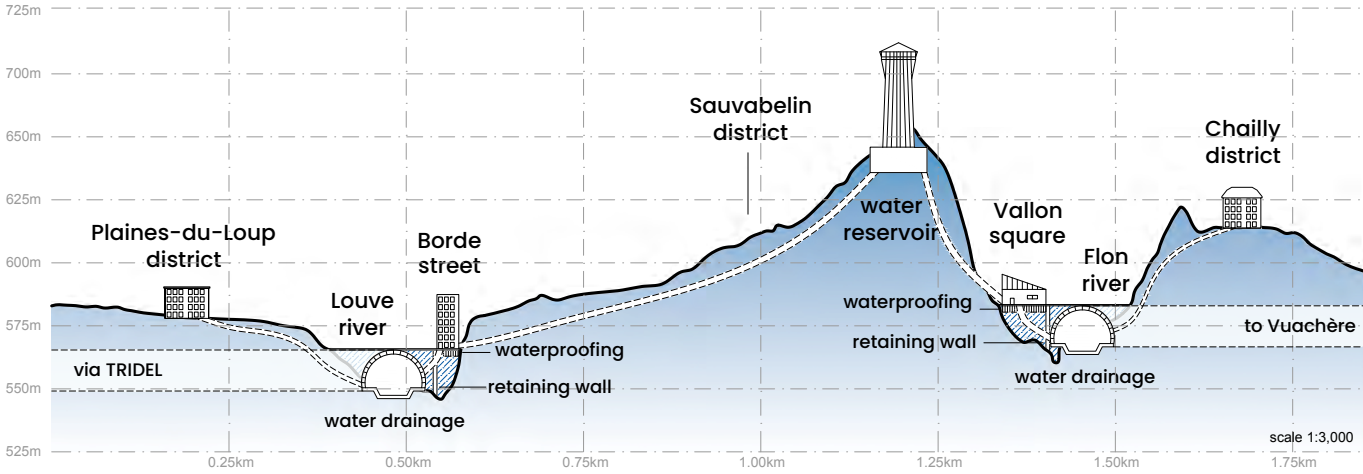
In the 19th century, Lausanne embarked on a major transformation of its hydraulic network with the vaulting of the Flon and Louve rivers. Between 1849 and 1850, vaulting of the Flon began at Saint-François, not only cleaning up the city but also freeing up valuable surface space. The vaulting of these watercourses also met a growing need: to manage rainwater in a city where steep gradients encourage rapid runoff. The torrents, transformed into underground sewers, became natural collectors for wastewater and rainwater. This system provides better flood control and prevents the frequent flooding that, in the past, devastated the lowest-lying districts. As seen in the images on p.13, it also allowed for improved connections linked to the evolution of car infrastructure.⁷

The Louve originates near Mont-sur-Lausanne, north of Lausanne, and descends through the Vallée de la Louve, where it is channeled underground. The river passes through what is now the Place de la Riponne and continued its course into the city center, eventually merging with the Flon. Since 2006, part of the water is been diverted into a conduit that passes through the newly constructed Tridel tunnel next to Sauvabelin, as shown in the section on the next page. The purpose of this diversion is to prevent clear water from entering the wastewater network, thereby improving the efficiency of the Vidy treatment plant.

The Flon follows a similar course. It originates near Epalinges in the north of Lausanne and flows through the Flon Valley, where it is also channeled underground. Historically, the Flon followed an open course through the area now known as the Flon District. It then meandered toward Malley, heading southward to join the Léman lake. Close to Sauvabelin, part of the water is artificially diverted to the Vuachère, a watercourse running further east of the city, via an underground conduit created in 1996. The other part flows through the Lausanne urban area, passing through the sewer network before reaching the Vidy wastewater treatment plant.

Lausanne’s sloping topography complicates water management. Stormwater drainage must take into account the significant differences in level between neighborhoods. As a result, the network is organized into zones, functioning like a large multi-storey building, with reservoirs and pumping systems to distribute water to the upper levels. For example, the Calvaire reservoir,

⁷ L. Polla, “De la Cité à Ouchy: Louis Polla Raconte la Naissance et la Vie des Places de Lausanne”.



Section: Terrain related to the water network.

⁸ H. Onde « La Pression du Relief sur l’Urbanisme Lausannois ».

⁹ J.-C. Biaudet, “Histoire de Lausanne”.

commissioned in 1868, illustrates these efforts to meet the growing needs of an expanding population. Recent works have also sought to improve runoff management and modernize the sewer network. Rehabilitation of the Flon vault, for example, is aimed at preventing blockages and adapting infrastructures to contemporary challenges, particularly those linked to urbanization and episodes of intense precipitation.⁸

Water supply has been a central issue for Lausanne since the 19th century, given its hilly topography and growing population. The introduction of pressurized water in 1868 not only ensured access to running water in most homes by the end of the century but also supported urban development in previously challenging areas by overcoming natural constraints. Public fountains, once vital for collective water access, became decorative elements, reflecting the city’s transition toward modern infrastructure.⁹

Water management in Lausanne is not limited to visible infrastructure. The foundations of buildings, often close to vaulted streams or sewers, must be adapted to prevent infiltration. Solid retaining walls, often inherited from medieval fortifications, hold back unstable ground and protect buildings from the effects of run-off. In the 20th century, urban expansion, particularly in the Flon valley, transformed this formerly marshy area into a center of commercial and industrial activity. These developments were part of a wider project to harmonize urban uses with the challenges imposed by water management, whether for drainage or supply.

Lausanne’s water network, from the first arched bridges to modern drainage and supply systems, illustrates the city’s ability to adapt to its terrain while integrating technological advances. The challenges

posed by water, omnipresent in a city built on rugged terrain, have stimulated technical and architectural innovations that continue to shape Lausanne today. By harnessing its streams and modernizing its infrastructure, Lausanne has transformed its natural constraints into elements structuring its urban development and identity. Thus, the water network's structuring power constrained the city's development, as it had to be channeled underground. This transformation allowed the next network, such as the road infrastructure, to emerge as the second most influential.



Image: The Cité as seen from Bessières, Musée de l'Ancien Evêché, c. 1870.



Image: The Cité as seen from Bessières, L. Polla, c. 1987.

ROAD NETWORK

As the second network influencer, the development of Lausanne's road network reflects the history of a city faced with unique geographical and urban planning challenges. From the start, Lausanne's topographical configuration imposed a particular organization of streets and roads. Unlike cities situated on flat terrain with fewer natural boundaries, which more easily lend themselves to tabula rasa planning and orderly visions such as grid systems or radial layouts, Lausanne's streets developed organically. The city's hilly, fragmented landscape dictated its street patterns, prioritizing practical adaptation to the terrain over centralized, majestic design ambitions.

The first roads linking the various medieval quarters, such as Rue de Bourg or Rue Saint-Laurent, followed the natural lines of ridges and valleys. These paths, often narrow and winding, were primarily suited for pedestrian and equestrian traffic. Nevertheless, they were also used for the transport of goods, although with considerable difficulty, requiring manual labor or pack animals to navigate the challenging terrain.¹⁰

Lausanne's steep gradients, particularly pronounced in streets such as Mercerie, were a major obstacle to smooth traffic flow. Slopes of up to 23% made travel difficult, particularly for carts and, later, motor vehicles. Wooden bridges, often washed away by flooding rivers such as the Flon and the Louve, further complicated communications between the various districts.¹¹

Despite these constraints, Lausanne's position at the crossroads of routes linking Italy, France and Germany fostered its development as a commercial and political center. Ancient roads, first used by the Romans and then by medieval merchants, converged on the city

¹⁰ J.-C. Biaudet, "Histoire de Lausanne".

¹¹ L. Grivel, « Historique de la Construction à Lausanne ».

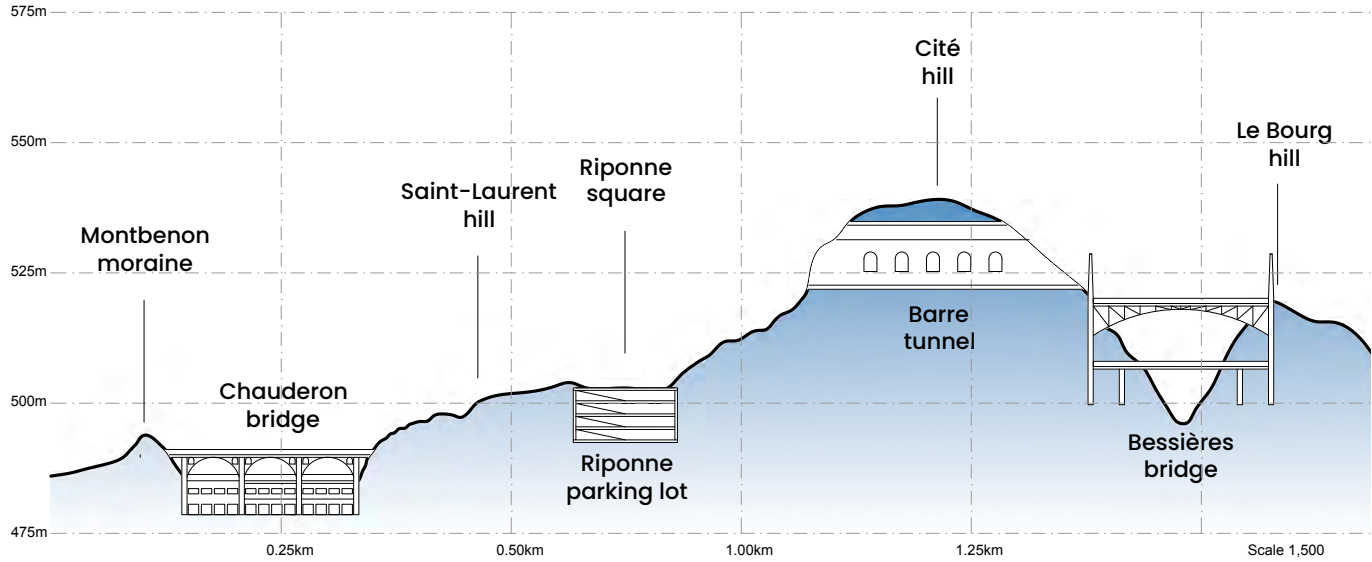
center, reinforcing its role as a regional crossroads. However, the lack of comprehensive planning and the natural obstacles of the terrain limited its expansion until modern times.

In the 19th century, Lausanne underwent a major transformation driven both by the challenges of its topography and the ambition to overcome them. The determination to bridge natural divides fueled the pursuit of technical progress and infrastructure modernization. The Pichard plan of 1836 marked a turning point by envisioning a road belt and the construction of a bridge and a tunnel to connect districts separated by the Flon and Louve valleys. These structures, such as the Grand-Pont, inaugurated in 1844, and the Barre tunnel in 1855 became emblematic elements of Lausanne’s urban planning, not only facilitating traffic but also symbolizing the city’s resolve to integrate its fragmented landscape.⁸

The vaulting of waterways in the 19th century not only transformed Lausanne’s urban landscape but also influenced the characteristics of the new roads built atop them. Thoroughfares like Rue Centrale and Place Centrale in 1879, created on these capped areas, were designed with a focus on accessibility and connectivity. Unlike the narrow, winding paths of the medieval quarters, these roads were wider, straighter, and better suited to accommodate the increasing demands of traffic, including horse-drawn carriages and later vehicles. Their flat, linear design contrasted sharply with Lausanne’s otherwise sloping terrain, becoming key axes for commercial and civic activities, and reinforcing the city’s shift toward modern urban planning.⁹

The development of rail and road infrastructures accompanied this transformation. The construction of the main railway station in 1856 strengthened Lausanne’s position as a regional crossroads, but also posed traffic challenges. Roads leading to the station, such as Petit-Chêne and Rue de la Grotte, were too steep and narrow to meet the growing needs of passenger and freight traffic. New roads, such as Avenue du Théâtre, were built to overcome these limitations and link the station to the city center.¹²

The rise of the automobile in the 20th century led to a profound reorganization of Lausanne’s road network. As seen on the images p.19, built between 1908 and 1910, the Bessièrès bridge connects the Cité hill to Le Bourg hill, thereby facilitating traffic between the east and west of Lausanne. The Chauderon bridge was inaugurated in 1905, and facilitated the development of public transportation, particularly trams, and contributed to the urbanization of the surrounding neighborhoods. The construction of avenues such as d’Echallens and de Provence, along with the creation of underground parking lots like those at Montbenon in 1961 and Riponne in 1972, exemplifies the city’s innovative adaptation to increasing traffic demands. As seen in the section, these initiatives are notable for their



Section: Terrain related to the road network.

¹³ J.-C. Biaudet, “Histoire de Lausanne”.

integration into Lausanne’s existing urban fabric, utilizing the city’s slopes and valley spaces to create multi-level infrastructure. The underground parking lots, in particular, reflect a forward-thinking approach to preserving surface space for public use and reducing visual congestion, all while accommodating the growing importance of vehicular mobility in an increasingly dense urban environment. Initiatives such as the green wave, introduced in 1964, aim to ease traffic congestion in a downtown area saturated with vehicles. However, these developments are not without environmental consequences, as demonstrated by the transformation of Flon and Riponne, which is having a lasting impact on the urban landscape.¹³

Lausanne’s road network reflects the city’s unique history and geography. Marked by major natural constraints, it bears witness to the ingenuity of urban planners and engineers who, over the centuries, have transformed these obstacles into opportunities. The bridges spanning the Flon and Louve valleys, such as the Grand-Pont, not only connected previously isolated districts but also redefined the city’s urban fabric. Roads like Rue Centrale and avenues d’Echallens and de Provence illustrate how the city adapted to evolving transportation needs, integrating modern solutions like underground parking into its hilly terrain. By linking the different parts of the city, incorporating new technologies, and preserving historic pathways like Rue de Bourg, Lausanne continues to develop while staying true to its identity, profoundly shaped by its topography and the creative solutions it inspired. While the road network has played a significant role, it is not the only structuring factor—another key element is the rail network, which will be explored in the next section.

¹² F. Studer, “Lausanne, Cité entre Flon et Louve”.



Image: The cable railway as seen from Ouchy, Collection Crispini, c. 1905.



Image: the rack railway allowing constructions above, L. Polla, c. 1987.

RAIL NETWORK

As a third network, the development of railroads in Lausanne reflects the challenges imposed by the city's complex topography and the need to overcome natural obstacles to connect this hilltop city to a rapidly expanding railway network in the 19th century. Lausanne's elevated position, steep hills, and deep valleys complicated the integration of an efficient rail infrastructure but also stimulated innovations that shaped its urban development.

The arrival of the railroads in Lausanne began in 1856 with the opening of a section to the city, but the beginnings were modest. The city's topography limited the choice of locations for stations and tracks, and the first station at La Rasude, situated on a relatively flat area, was chosen by the Compagnie de l'Ouest. However, it was criticized by residents for being inconveniently located on the outskirts, as they preferred central sites like the Flon valley or Montbenon. These more central areas were difficult to access due to the steep terrain and existing urban structures, demonstrating the constraints of Lausanne's geography on early planning.

Despite these initial challenges, Lausanne's rail network developed rapidly. The opening of the line to Saint-Maurice in 1861, which required extensive engineering to navigate the hilly terrain, marked an important milestone. From 1869, the realignment of passenger trains through Lausanne reinforced its role as a major rail hub, bypassing the less advantageous Morges-Bussigny route and addressing some of the topographical challenges of earlier planning.

At the same time, the Lausanne-Echallens-Bercher (LEB) line, inaugurated in 1874, further illustrates how topography shaped the city's rail development. Designed to connect Lausanne with the Gros-de-Vaud, this line faced significant financial and technical obstacles

due to the need to navigate steep inclines and narrow valleys. Even though it begins its course from the Flon at Avenue d'Echallens underground in a large subterranean tunnel, as shown in the image on p.28, its narrow gauge allowed for better adaptation to the undulating terrain. However, this also isolated the line from the standard-gauge Swiss rail network, preventing direct connections to Lausanne's main station. The financial success of the LEB was only achieved with industrial support and the extension to Bercher.¹⁴

The 20th century saw the acceleration of these transformations with the introduction of public transport and the development of the automobile. The Lausanne-Ouchy tramway, inaugurated in 1887, was one of the first in Switzerland to be electrified, testifying to the modernity of Lausanne's infrastructure. As seen in the images on p.24, the tramway lines, adapted to the city's slopes, play a crucial role in connecting the various districts and reducing inequalities in access caused by the terrain. Additionally, the vaulting of these lines later facilitated construction above them.

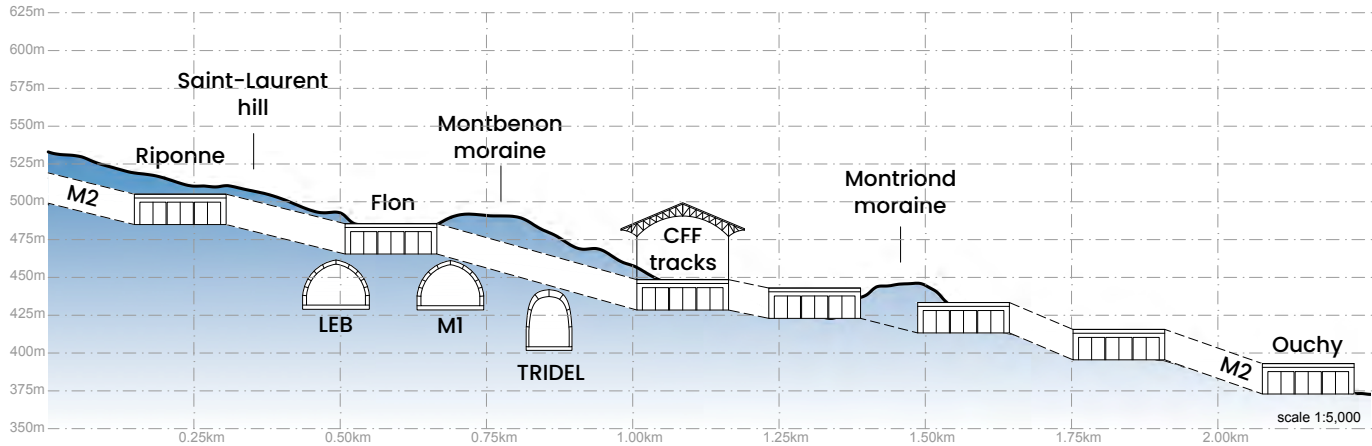
The creation of the Lausanne-Ouchy tunnel represented an innovative solution to Lausanne's topographical challenges, particularly the significant elevation difference of approximately 100 meters between the lakeside and the city center. This steep gradient made the transport of goods and passengers labor-intensive and inefficient. The tunnel, inaugurated under the initiative of Jean-Jacques Mercier, established a direct, efficient link between the port at Ouchy and the urban hub of Lausanne, transforming both commerce and logistics in the city.

By providing a subterranean route, the tunnel allowed goods to move seamlessly uphill without clogging narrow, winding streets or relying on slow, manual transportation methods. This minimized urban pollution and freed surface streets for other uses. Furthermore, the development of the Flon valley as an industrial and commercial zone leveraged the flat land created by successive fillings, creating an ideal location for expanding warehouses, factories, and other facilities. These industrial activities benefitted directly from the efficient connection to the lakeside via the tunnel.

This project highlighted Lausanne's ability to adapt its infrastructure to the challenges of its hilly terrain. The tunnel's construction not only resolved a critical logistical issue but also marked a turning point in urban planning, reshaping the Flon valley into a vibrant central district while relieving congestion around the main railway station by redistributing commercial activity.

In 1927, the opening of the Sébeillon freight station marked a significant step forward in Lausanne's railway and logistical infrastructure. Situated to the west of the city, the station was strategically positioned in a flatter area compared to the steep terrain

¹⁴ J.-C. Biaudet, "Histoire de Lausanne".



Section: Terrain related to the rail network.

surrounding the main station, where growing traffic had created logistical bottlenecks. This flatter topography made Sébeillon ideal for handling freight operations, allowing for the storage and distribution of goods on a larger scale.

Lausanne's central railway station, which was constrained not only by increasing traffic but also by its location in a more densely built and uneven area. By leveraging the relative ease of construction and operation in Sébeillon's terrain, the station became a nerve center for goods transport, supporting Lausanne's role as a regional economic crossroads. This strategic use of Lausanne's varied topography underscores the city's innovative adaptation to its natural landscape in expanding its infrastructure.

Today, Lausanne continues to adapt its infrastructure to its challenging relief to meet the growing mobility demands of its population. The M1, Lausanne's first metro line, traverses a terrain characterized by gentle slopes and interfluves. Built in 1991, the M1 primarily follows a surface-level alignment, avoiding the steep inclines and sharp elevation changes that define other parts of the city. By integrating existing railway corridors and strategically employing bridges and underpasses to navigate valleys and obstacles, such as the Montbenon moraine, the M1 efficiently connects Lausanne's city center to the university campuses of UNIL and EPFL, extending westward to Renens. This design not only respects the natural contours of the land but also provides a vital link for suburban and peri-urban mobility.

Recenter projects, such as the M2 in 2008, Switzerland's first and only automatic metro, exemplify the city's innovative approach to overcoming its natural constraints. The M2 crosses the city from

south to north, navigating the steep hills through a series of tunnels and viaducts, which allow it to traverse dramatic elevation changes efficiently from Ouchy with 373 m and Croisettes with 711 m.

What makes the M2 particularly notable is its adaptation to Lausanne’s verticality. Stations are closely spaced in steep sections, such as between Ouchy and the city center, to make the metro accessible for passengers navigating the steep terrain on foot. The M2 handles an elevation difference of nearly 336 m over its 6 km length, with the depth of stations below ground varying significantly. For example, Ouchy station is near the surface at lake level, while Flon and Riponne-Maurice Béjart stations are located deeper underground to accommodate the city’s hills.

The steepest gradient on the line reaches an impressive 12%, making the M2 one of the steepest metro systems in the world. This requires advanced engineering, including powerful automated braking and acceleration systems, to ensure safe and efficient operation. The design of the M2 reflects a profound understanding of Lausanne’s topographical constraints, offering a modern solution to a road network historically limited by the city’s rugged terrain.

Despite this progress, Lausanne’s topography continues to pose significant challenges for rail infrastructure, as evidenced by the ongoing renovation of Lausanne Gare. Originally planned as a necessary expansion to accommodate increasing passenger numbers and improve connections, the project has been marked by delays, budget overruns, and technical complications, underscoring the enduring difficulties of adapting infrastructure to the city’s steep and fragmented terrain.

The renovation project involves expanding platforms and adding new tracks, which requires significant excavation and restructuring. However, the station’s location between Montbenon and Montdriond moraines, and dense urban development, has severely limited construction options, leading to logistical difficulties and higher costs. The complex underground utilities network, including tunnels has added another layer of complexity to the project. This “fiasco,” as it has been described by critics, highlights how Lausanne’s topography continues to shape and sometimes hinder urban and transportation development, even in the modern era.

The Tridel tunnel is also tied to the city’s unique topography. Carved through Lausanne’s complex relief, the tunnel channels waste and the Louve water 50 m beneath the surface, addressing the challenges posed by the city’s steep slopes and uneven terrain. This underground conduit connects the urban drainage network from the Sébeillon station to the Tridel waste-to-energy plant, where waste is converted into electricity and heat. By redirecting waste underground, the tunnel opens up a new surface space for urban



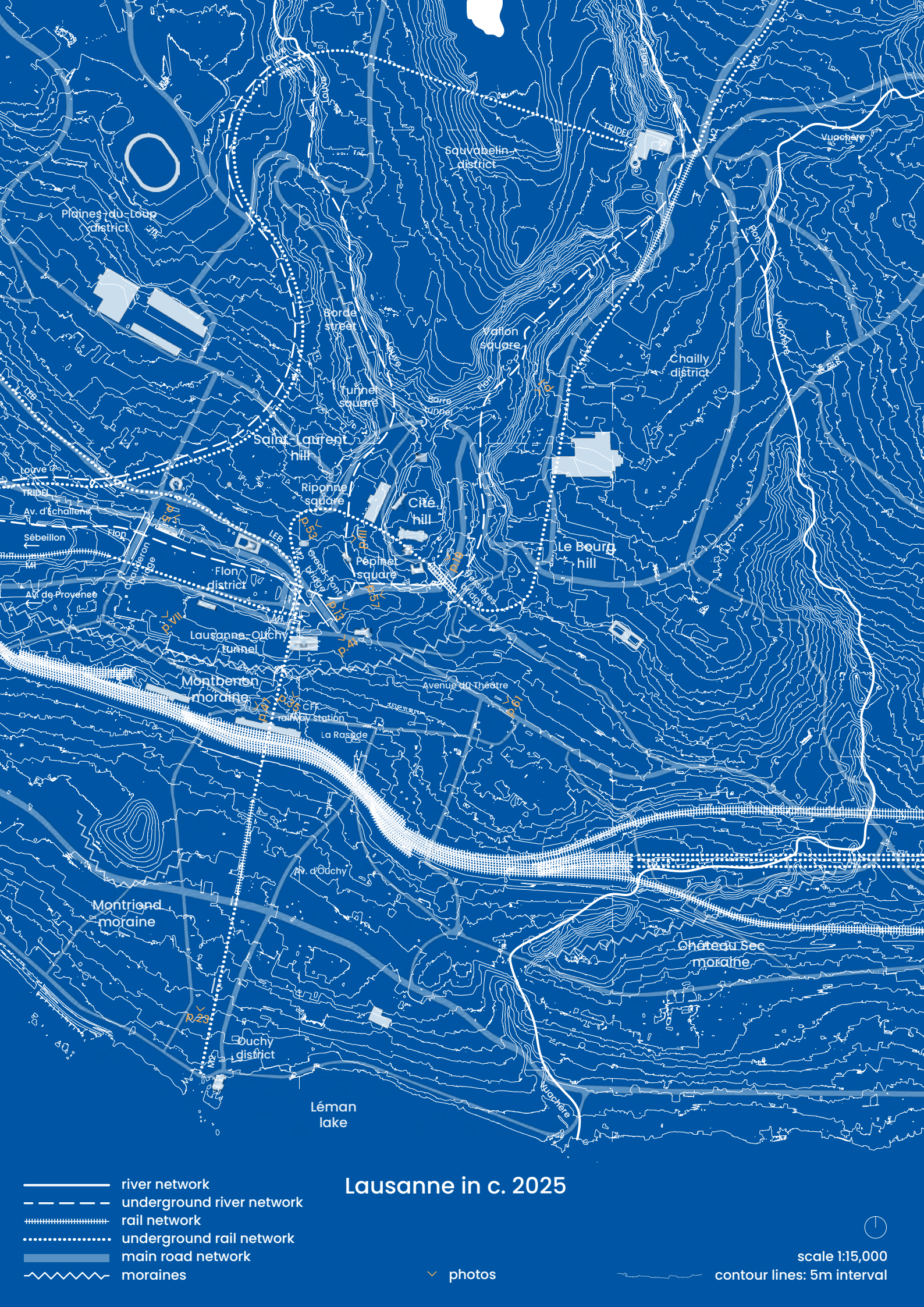
Image: LEB under Echallens street, vd.ch, 2022.

development, but also eliminates the need for truck traffic on the surface, reducing congestion and preserving the urban environment.

The development of the rail network is part of a modernization dynamic that goes beyond the simple transport of people and goods. It has a direct influence on urban organization, stimulating the development of new districts around stations and railroad lines. Lausanne’s economic center gradually shifted south and west, following the axes defined by the railroads and their infrastructure. This trend is set to continue with the introduction of the future tram network, which will further enhance connectivity between the city center and its surrounding neighborhoods. The tram, designed to integrate seamlessly with existing transport systems, will not only provide an efficient means of transit but also serve as a catalyst for urban renewal and densification along its route. By linking key areas and fostering new developments, the tram underscores Lausanne’s commitment to sustainable urban planning and its ongoing adaptation to the challenges of modern mobility.

Today, Lausanne’s railway heritage remains visible in the city’s structure and its role as a regional crossroads. Passenger and freight rail lines continue to shape the city differently, with above-ground freight hubs like Sébeillon supporting industrial activities, while below-ground metro and regional rail lines prioritize passenger mobility and urban integration. The M2 metro, with its steep gradients and closely spaced stops, connects neighborhoods separated by elevation, while the regional rail network links Lausanne to other cities in Switzerland, fostering economic growth beyond its borders. The future tramway, operating on the surface, will offer localized connections and contribute to urban densification around their routes.

These layered systems reflect how Lausanne has leveraged its topography not merely as a constraint, but as an opportunity to develop a multi-level transportation network, as illustrated in the section on p.26, which highlights the extensive underground railway infrastructure. Rail infrastructure, whether above-ground, below-ground, or integrated into the urban fabric, has helped Lausanne assert itself as a strategic node in the Swiss transportation network. This network, forged by centuries of adaptation to the city's challenging terrain, is a testament to the ingenuity and resilience that continue to shape Lausanne's identity and development.



FACT SHEET

RELIEF

c. -11,000: retreat of the **Rhône Glacier**

4th: from Lousonna to the **Cité hill**

1956: **Infilling** of the Flon valley

373 - 901 m: **Lausanne** from the Léman lake to Chalet-à-Gobet

30 m: **Louve** valley depth between Sauvabelin and Plaines du Loup

60 m: **Flon** valley depth between La Sallaz and Sauvabelin

25 - 40 m: **Montbenon** moraine height from to the Flon riverbed

WATER

1830: most significant **flood** of the Louve

1832: **cholera** epidemic linked to the unsanitary Flon and Louve

1837: vaulting of the Louve from **Saint-Laurent** to **Place de la Palud**

1849: vaulting of the Flon in **Saint-François**

1865: vaulting of the Louve in **Valentin**

1867: vaulting of the Louve in **Tunnel**

1869: vaulting of the Flon from **Pépinet** to **Grand-Pont**

1873: vaulting of the Louve until the **Riponne**

1875: vaulting of the Flon from **Bessièrès** bridge to **Pépinet**

1876: vaulting of the Flon at **Gare du Lausanne-Ouchy station**

1876: vaulting of the Louve in **la Borde**

1878: vaulting of the Flon in the **Flon district**

1880: vaulting of the Flon from **Saint-Martin** to **Tunnel**

1890: **final vaulting of the Louve** further than la Borde

1921: **final vaulting of the Flon** until the Léman lake

1996: diverting part of the Flon to the **Vuachère**

2006: **Tridel tunnel** diverting part of the Louve

ROADS

23%: one of the steepest streets **Mercerie** street

1836: **Pichard Plan** road belt to integrate the urban landscape

1844: **Grand-Pont** linking Saint-François to Bourg

1855: **Barre tunnel** across the Louve valley

1905: **Chauderon bridge** Flon valley

1910: **Bessières bridge** connecting the Cité and Bourg hills

1962: **Montbenon** parking spanning multiple levels

1964: **Green Wave Initiative** designed to alleviate traffic congestion

1950s: **Trolleybuses** into Lausanne’s transport system

1972: **Riponne** parking spanning multiple levels beneath the square

RAIL

1856: **Main Railway Station** establishing as a regional crossroads

1874: **Lausanne-Echallens-Bercher** connecting with Gros-de-Vaud

1877: **Lausanne-Ouchy Tramway** one of the first electrified

1927: **Sébeillon Freight Station** supporting freight operations

1991: **M1** connecting the city center with UNIL and EPFL

2006: The **Tridel** waste incineration plant

2008 M2 connecting it to the modern mobility network

6 km: **M2** length

373 - 711 m: **M2** from Ouchy to Croisettes

12%: steepest gradient of the **M2**, one of the steepest in the world

5.7%: average gradient of the **M2**

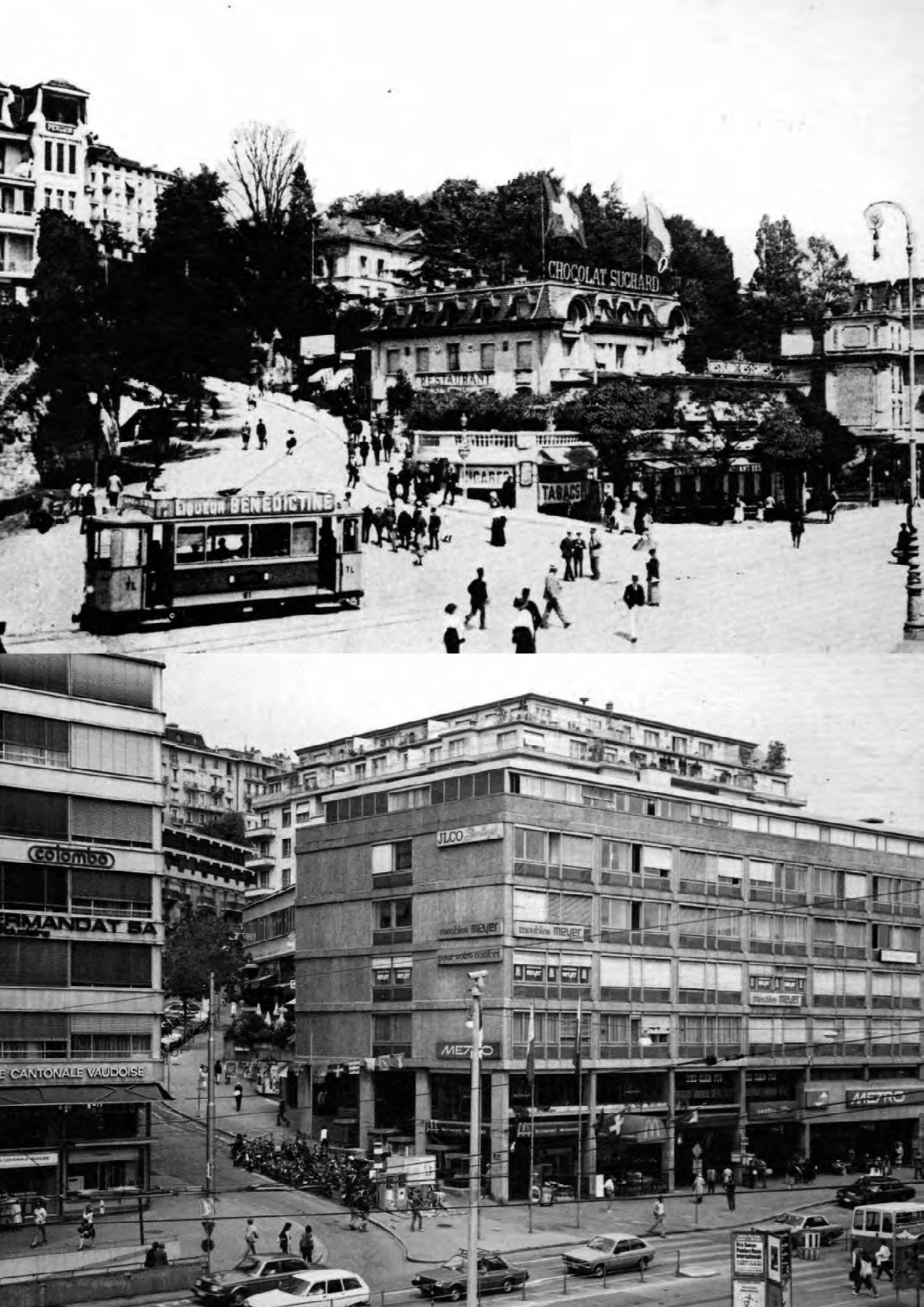


Image: Petit-Chêne Avenue on a slope
Carte postale, L. Polla, c. 1910.

CONSTRUCTION STRATEGIES

Having seen several of the city's structuring networks, it's now possible to appreciate the possibilities offered by a territory with a particular relief. The use of the subsoil in Lausanne reflects a long history of human adaptation to the unique topography and constraints imposed by a complex urban environment. Since prehistoric times, man has exploited the subsoil to meet a variety of needs, from protection against natural elements or enemies, to the exploitation of mineral resources, to the creation of underground structures designed to improve traffic flow and the organization of urban space.

In the earliest phases of human history, caves served as natural refuges, offering protection from the rigors of the glacial climate and predators. These primitive shelters were sometimes modified to better meet the needs of their occupants, marking the beginnings of underground development. With the advent of civilizations, the exploitation of underground resources, such as water, minerals, and metals, became increasingly important. Wells for water supply and quarries for building materials represent some of the first human interventions in the underground domain.

Burial practices also played a crucial role in shaping early architecture, as the underground became a space not only for survival but for ritual. Adolf Loos, in his writings, identified the burial mound as the origin of architecture, pointing to its dual role as both a marker of the human need for commemoration and a demonstration of an aesthetic response to death.¹⁵ From prehistoric barrows and tombs to the monumental necropolises of ancient Egypt, these early interventions reflect humanity's profound relationship with the subterranean, both as a source of life and a resting place for the dead.

¹⁵ A. Loos, « Architecture ».

Image: Petit-Chêne Avenue on a slope
L. Polla, c. 1987.

Lausanne’s subsoil has played a crucial role in the city’s development, not least because of its particular topography. As far back as antiquity, underground infrastructures such as pipes and sewers were developed to meet the growing need for sanitation and water supply. These transformations were carried out using advanced techniques for the time.

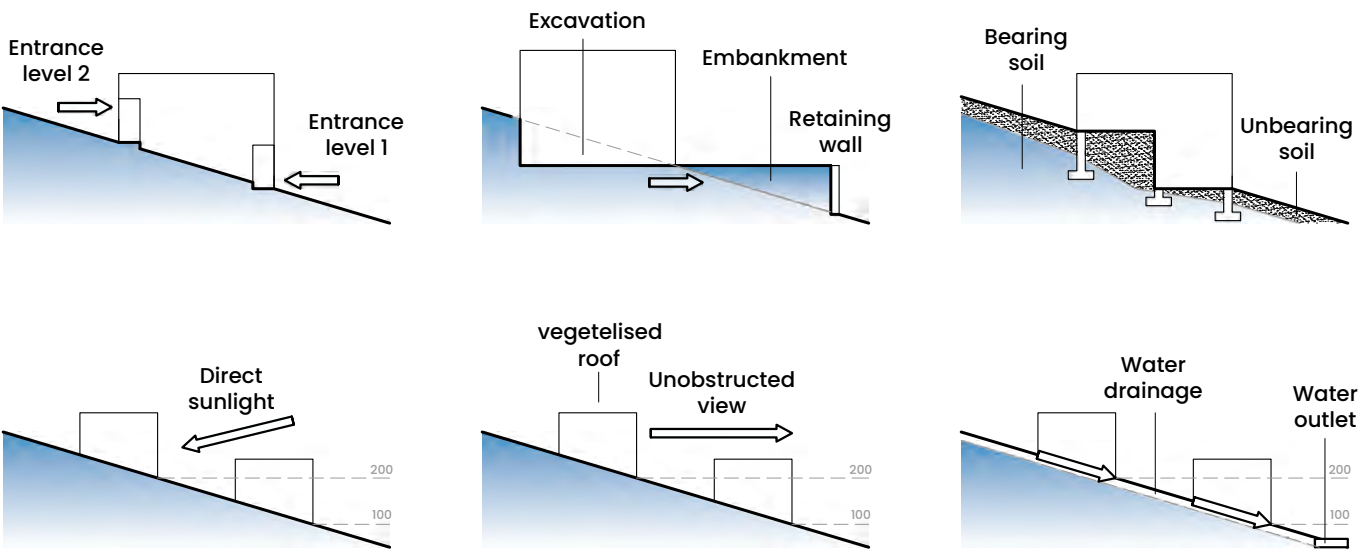
Modern underground urbanization emerged as a solution for optimizing the use of space in increasingly dense cities. In Lausanne, underground parking lots such as those at Montbenon and La Riponne, along with underground public transport stations, illustrate this trend. These developments go beyond simply filling existing gaps; they involve the deliberate creation of underground spaces, effectively expanding the city’s usable area. By moving utilitarian functions underground, such as parking, transport, and storage, the surface is freed for public spaces, green areas, or more visually appealing developments.

This approach not only densifies the city vertically but also allows for multifunctionality, where a single footprint serves both surface and subterranean purposes. In Lausanne’s case, these interventions are particularly striking given the city’s hilly topography, where the underground is actively carved out to integrate with the natural terrain, exemplifying the modern drive to reimagine and maximize urban space. Instead of merely building around or over the hills and valleys, Lausanne integrates the underground into its infrastructure, using it as a functional part of the city.

At the same time, Lausanne’s subsoil has been home to industrial and commercial infrastructures, such as the Flon area, which historically served as a hub for warehouses and goods transport due to its proximity to the railway and underground connectivity. Today, the Flon has been transformed into a modern business and cultural center, while still retaining elements of its historic role as a logistical and commercial nexus.¹⁶

Adapting to the terrain has also encouraged the use of the underground for innovative architectural projects. For example, the Palais de Rumine onn the Riponne square, situated between two levels of land, makes intelligent use of the topography to offer distinct entrances at different levels. This approach, which allows buildings to blend harmoniously into their environment, has continued with other modern constructions. These examples show how Lausanne has turned a challenge into an opportunity, using the underground to meet functional needs while respecting the specific features of its terrain.¹⁷

This diagram illustrates various strategies for integrating architecture into sloped terrains, particularly relevant to Lausanne’s topographical challenges. The first section highlights the use of



Diagrams: Construction strategies on a slope.

multiple entrance levels, optimizing accessibility and maximizing the connection between the structure and the terrain. The use of retaining walls and excavation techniques is shown as a solution to stabilize the slope while providing solid foundations on bearing soil, avoiding instability caused by unbearing soil.

Furthermore, the diagram emphasizes the benefits of a sloped terrain for natural light exposure, as direct sunlight can be maximized. Additionally, as seen in the images on p.33 of the dense northern part of the main station, it emphasizes the importance of unobstructed views, achieved through the staggered heights of the buildings, with each structure positioned slightly higher than the one below. This design ensures clear sightlines across the terrain while also taking into account the roofscape, which becomes an integral visual element when observed from above. Finally, the integration of waterproofing, water drainage, and water outlets ensures the management of water flow, preventing erosion and structural damage, and reflecting a careful adaptation to the natural slope. These techniques exemplify how innovative design can harmonize built forms with challenging landscapes.

Underground development is not limited to physical infrastructure. It also reflects a broader vision of the interdependence between above and below. This relationship, long perceived as dichotomous, is now evolving towards an integrated understanding, where the subsoil is seen as a natural extension of the surface. The underground metro line M2 is connected to surface bus lines, future tramway, and the mainstation, creating a seamless flow of movement across different layers of the city. Also, underground pipelines transport heat generated by facilities like Tridel to homes and businesses on the surface.

¹⁶ E. Utudjian, “L’Urbanisme Souterrain”.

¹⁷ H. Onde, « La Pression du Relief sur l’Urbanisme Lausannois ».

In most cities, including Lausanne, underground infrastructures play a crucial role in the circulation of water, energy, and data. These networks, often hidden from view, form the backbone of modern urban life, enabling essential services such as water supply, electricity distribution, telecommunications, and internet connectivity. In Lausanne, this subterranean infrastructure is intricately adapted to the city’s topography, ensuring efficient service delivery even in a challenging hilly environment. It physically and symbolically links the city to its vertical dimension. This three-dimensional approach, combining horizontal and vertical axes, redefines urban planning practices and offers new perspectives for future development.

The increasing use of the subsoil for urban purposes also reflects modern concerns about sustainability and resource optimization. Lausanne’s soils, composed of heterogeneous glacial layers and molasse, present technical challenges that require rigorous planning. However, these geological features also offer unique opportunities, particularly for energy storage and waste management. The rational and sustainable exploitation of Lausanne’s subsoil, supported by legal regulations and technological advances, is helping to shape a city that is better adapted to the challenges of the 21st century.¹⁸

In this way, the history and future of Lausanne’s subsoil use bears witness to the city’s ability to take advantage of its natural constraints to innovate and evolve. Whether to meet the basic needs of residents, improve infrastructure or reimagine urban space, the subsoil remains an invaluable resource, both functional and symbolic, for the city’s harmonious development. Following on from these few aspects, it’s now possible to focus in greater detail on certain locations in Lausanne.

¹⁸ S. Berger Ziauddin, “Sous le Sol : Une Histoire d’Interdépendances Verticales”.



Image: The Flon Valley as seen from the Grand-Pont, Musée de l'Ancien Evêché, c. 1870.

Image: The Flon Valley as seen from the Grand-Pont, L. Polla, c. 1987.

LE FLON

The Flon valley, with its different levels and land uses, is a prime example of how the potential of relief can be exploited to the full. The Flon valley, once considered a natural obstacle to Lausanne's urban development, was the subject of numerous development proposals over the course of the 20th century, reflecting the desire to transform this area into a functional space integrated into the city's economic and social life. As early as 1902, the municipality proposed an ambitious project to fill in the valley along an inclined plane running from Lausanne-Ouchy station to Sévelin, at the level of the CFF tracks linking Lausanne to Geneva. This initiative is part of a vision of modernization and economic development, seeking to use this area to support Lausanne's industrial and commercial expansion.

The initial aim was to attract industrial and commercial activities to the Flon valley, while relocating the CFF freight station there. This strategy, discussed between 1904 and 1919, was designed to convince skeptics of the importance of this project for the city's industrial development. However, the work required to transform the valley, notably earthworks and the addition of embankments, gave rise to debates about their technical feasibility and cost.

One proposal, put forward by Charles Zbinden, stood out for its innovative approach: replacing the planned embankments with retaining structures. This concept considerably reduces the volume of fill required, from 1.4 to 1.6 million cubic metres to around half. The interlocking terraced constructions facilitate access to the resistant subsoil layers, stabilize the upper road and reduce the risk of landslides. This pragmatic solution incorporates efficient use of locally extracted materials, while offering optimized levelling for the terrace bottoms.

The aesthetic dimension also plays an important role in the proposals for the Flon valley. The panoramic view from the Chauderon bridge, offering a perspective over the Vaud plain, Lake Geneva and the Jura, is seen as a precious visual heritage to be preserved. However, it is also necessary to make the close-up view of the planned buildings in the valley attractive. Tiled roofs, with moderate slopes and simple decorative elements, were proposed as an alternative to terraces, which are often subject to waterproofing problems and aesthetic degradation from weathering and pollution. This approach combines functionality and visual harmony, taking into account Lausanne residents’ expectations of the urban landscape.¹⁹

The transformation of the Flon Valley into a modern urban district was guided by a set of design principles that balanced its industrial heritage with contemporary needs. These principles shaped the district’s character and functionality, ensuring its integration into Lausanne’s urban fabric while respecting its unique topography.

As seen in the images p.41, the original warehouse buildings in the Flon district adhered to strict height regulations, ensuring uniformity and creating a cohesive architectural language. This legacy has influenced modern developments, where building heights remain controlled to preserve views of the surrounding hills and maintain a sense of scale within the valley.

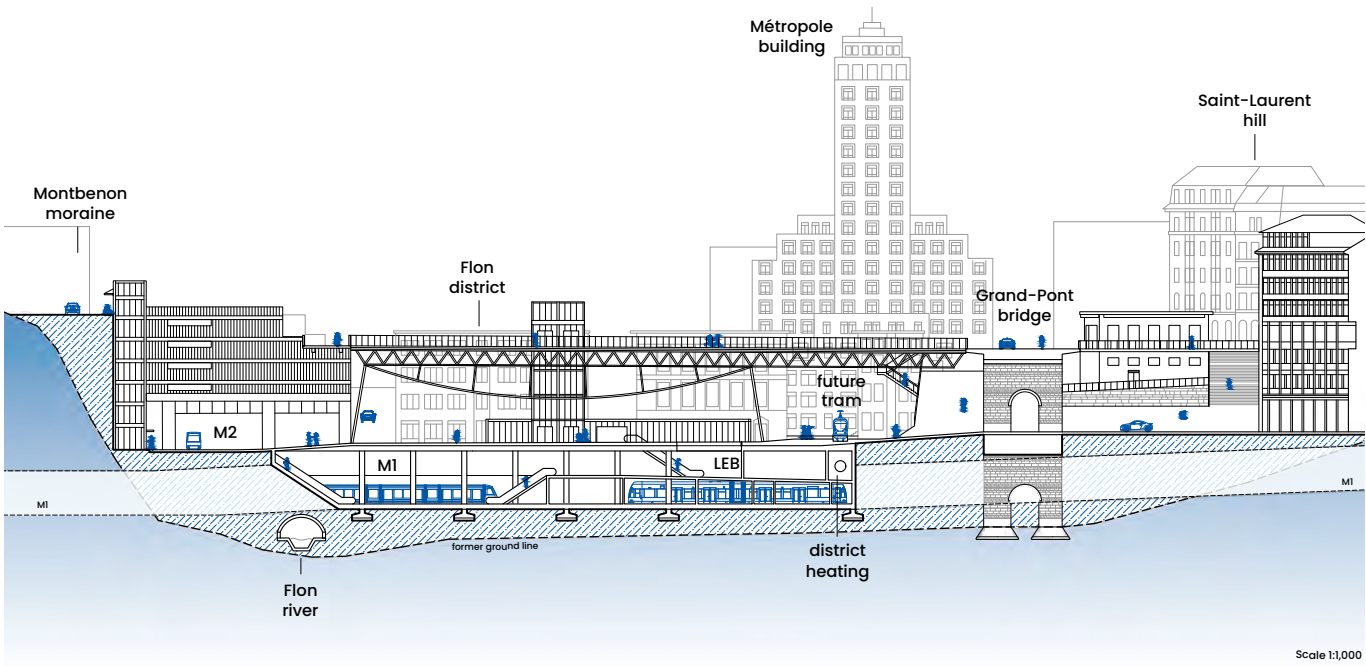
The Flon district features a distinct grid pattern, a rarity in Lausanne’s otherwise organic and topography-driven urban layout. This structured approach allowed for efficient land use and facilitated the organization of transport, pedestrian pathways, and utility networks. The grid also aligns with the valley floor, emphasizing its flatness in contrast to the steep slopes of the surrounding city.

The Flon district capitalizes on its subterranean potential, with multiple layers of activity beneath the surface. Underground parking, logistics spaces, and transport infrastructure coexist with above-ground cultural, commercial, and residential activities. This multi-level design allows the district to handle high density without overwhelming the surface environment.

Connecting the valley floor to Lausanne’s surrounding hills posed a significant challenge. Key structures, such as the Métropole building, serve as bridges between different elevations, integrating pedestrian and vehicular access. Escalators, elevators, and stairways have been strategically positioned to provide seamless transitions between the valley and adjacent neighborhoods.

The Flon district’s redevelopment prioritized creating open public spaces, such as plazas and pedestrian-only zones, within a densely built environment. These spaces offer respite from urban activity

¹⁹ C. Zbinden, “Aménagement de la Vallée du Flon: Projet Municipal”.



Section: Flon valley.

while enhancing connectivity between buildings and transport hubs.

This section illustrates the layering and interconnected systems within the Flon’s urban infrastructure. It highlights the integration of various transportation networks, including the M1 and M2 metro lines, the LEB train line, and the planned future tramway, all operating beneath the surface to optimize space and improve connectivity. The Flon river, channeled underground, for urban development. The district heating system further exemplifies the city’s innovative use of underground spaces to support sustainable energy solutions. Above ground, the Grand-Pont bridge connects key parts of the city while maintaining unobstructed views across the Flon district and linking it to the historic Saint-Laurent hill and Montbenon moraine. This design reflects Lausanne’s ability to balance modern infrastructure with its challenging topography, creating a dynamic, multi-level urban environment.

By adhering to these principles, the Flon Valley has successfully transitioned from an industrial hub to a vibrant urban district that accommodates modern living while navigating Lausanne’s complex topography. Its design offers a model for reimagining urban spaces in dense and challenging terrains.

The solutions proposed reflect a balance between technical constraints, economic requirements and aesthetic concerns, while respecting the city’s unique character and the expectations of its residents. This transformation, while ambitious, illustrates Lausanne’s ability to adapt its urban planning to the challenges of its topography and to meet the growing needs of modernization and economic expansion. The Flon valley, now a dynamic hub of

activity, bears witness to this evolution and to the ingenuity of the solutions devised to take advantage of available resources while respecting the city’s visual and cultural identity. The Flon valley also has a close link to Lausanne station, which is connected to it by the underground network.



Image: The train station square
Musée de l'Ancien Evêché, c. 1908.

LA GARE

The railway station is another interesting symbolic site, built on a slope and taking advantage of the gradient despite the constraints of the rail line. Located in the heart of a city with a complex topography, Lausanne railway station is an emblematic example of how urban planning in Lausanne has adapted to its geography to meet the needs of a modern railway infrastructure. Place de la Gare in Lausanne is a central urban space situated in a natural depression, known as a talweg, which channels water flow through the area. This topographical feature extends from the square down to Avenue d'Ouchy, facilitating natural drainage.

The square is approximately 100 m in length and 40 m in width, covering an area of about 4,000 m². These boundaries position Place de la Gare as a pivotal point connecting various parts of the city. The square serves as a major hub for public transportation, including trains, buses, and the M2. This topography has influenced the orientation of the city, facilitating the connection between the urban center, the train station and the Léman lake.

As soon as the railroad arrived in Lausanne in May 1855, the city realized the strategic importance of this new infrastructure. This first convoy, linking Léman Lake and Lake Neuchâtel, marked the beginning of a new era of mobility and communication for Lausanne. However, the station's initial facilities were rudimentary, adapted to immediate needs but with no long-term vision. Successive railway companies, faced with a rapid increase in traffic, proceeded with improvised extensions, often carried out in a hurry and without overall coordination. This lack of planning limited the station's potential to become a genuine rail hub.

The situation changed radically in 1903, when the Swiss Federal



Image: The train station square with
underground pedestrian pathways
L. Polla, c. 1987.

Railways (CFF) took control of Lausanne's rail network and committed to building a passenger station befitting the city's ambitions. Today, CFF continues to influence Lausanne not just as a transport operator but as a potential urban developer.

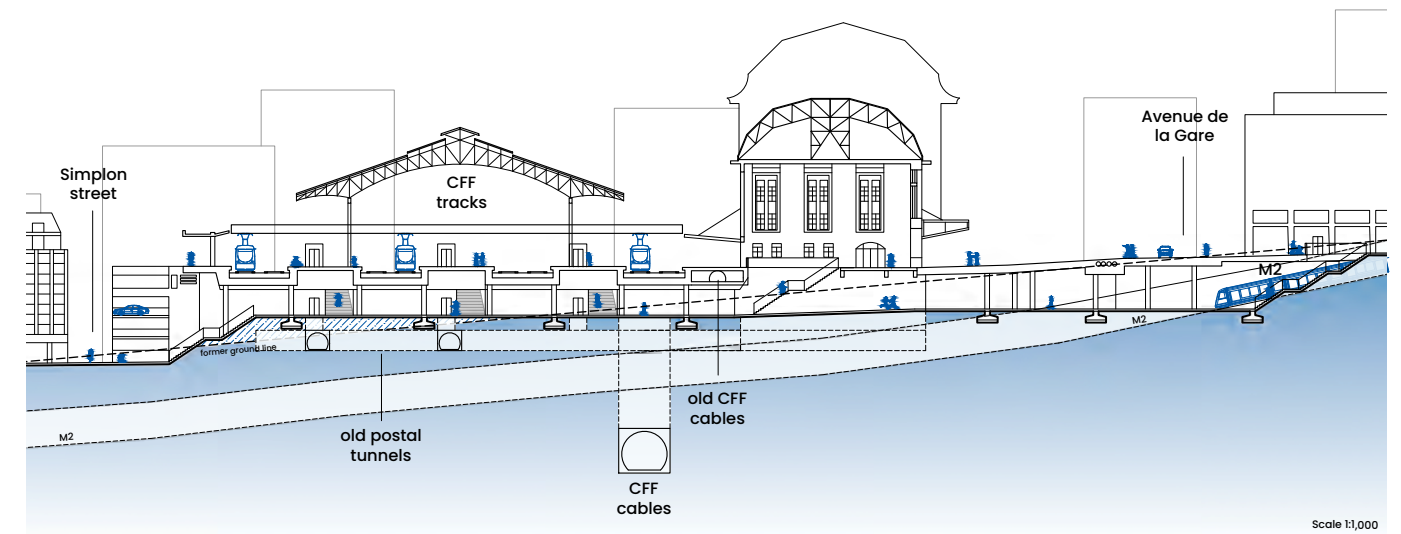
Across Switzerland, CFF has undertaken major urban redevelopment projects, such as Zurich's Europaallee, Basel's Südpark, and Geneva's Pont-Rouge, which have reconfigured urban areas by creating mixed-use developments on CFF owned land. These projects often include residential, commercial, and cultural spaces, tightly integrated with transport infrastructure, contributing to urban densification and economic vitality.

In Lausanne, the ongoing renovation of Lausanne Gare offers a glimpse of CFF's potential as an urban developer. The project involves not only expanding the station to accommodate growing passenger numbers but also reimagining the surrounding areas, including Place de la Gare, to improve connectivity and enhance urban life. CFF's extensive landholdings around the station present an opportunity for larger-scale redevelopment that could transform the city's center, potentially following the model of developments seen in other Swiss cities.

However, Lausanne's unique topography and existing urban fabric pose challenges to such an ambitious transformation. The hilly terrain and dense development around the station leave less room for expansive projects compared to flatter cities like Zurich or Geneva. Any significant reconfiguration would require creative architectural solutions to navigate these constraints, potentially integrating multi-level designs that capitalize on Lausanne's verticality.

Connected to the CFF, La Rasude is a significant urban area located to the east of Lausanne's main railway station. Historically, it has been a hub for administrative and logistical activities with beneath the railway station a complex network of underground structures, including historical postal tunnels. These tunnels, once integral to postal operations, are situated above the Lausanne metro level but below the station's underpasses and railway tracks. In recent developments, the CFF has undertaken projects to fill these disused tunnels with concrete to provide solid anchorage required for major construction works, including the reconstruction of five platforms and the creation of three new underpasses.

The project for Lausanne Gare in the early 20th century was designed not only to meet the functional needs of a modern station but also to reflect Lausanne's growing prominence on the international stage, particularly with the imminent opening of the Simplon line in 1906, linking the city to the European rail network. However, the station's architecture had to navigate the city's challenging topography, resulting in a layout that is somewhat unconventional.



Section: Railway station.

Unlike many train stations where the main façade faces downhill to embrace the city, Lausanne Gare presents its primary entrance uphill, toward Avenue de la Gare. This orientation reflects the constraints of the sloping terrain, which dictated that the station align with the ridge running through the city rather than the valley below. While this uphill façade serves as the primary entrance, it limits the station's ability to create a grand, open plaza typically associated with train stations of similar stature. Instead, the space in front of the station is compressed, with much of the area given over to traffic infrastructure, including roads, buses, and metro access, leaving little room for the kind of expansive public square that might otherwise serve as a civic focal point.

The downhill side of the station, which descends toward Simplon street, functions largely as a service and secondary access area, emphasizing the station's role as a transportation node rather than a ceremonial gateway. The lack of a significant plaza on either side highlights the limitations imposed by Lausanne's terrain, where steep slopes and dense urban development constrain the possibilities for expansive open spaces.

The section illustrates the layered complexity, showcasing how infrastructure has been integrated into the city's sloped terrain. The CFF tracks dominate the surface, forming the backbone of the railway network that connects Lausanne to regional and international destinations. Below ground, are situated the old postal tunnels and the CFF cable conduits (image p.52), which highlight the historical adaptation of underground spaces for logistical and communication purposes. The M2 metro line, further below, exemplifies modern transit solutions designed to navigate Lausanne's steep topography efficiently.

Despite these challenges, Lausanne Gare’s architecture manages to integrate the station into its surroundings through multi-level access points and vertical circulation systems. Elevators, staircases, and connections to the underground metro station reflect a layered design approach, maximizing usability in a compact and challenging site. While the architectural configuration sacrifices some of the grandeur associated with train stations in flatter cities, it succeeds in adapting to Lausanne’s topography, serving as both a functional transport hub and a symbol of the city’s growing connectivity to the European rail network.

Although, the city’s orientation toward the station accelerated with its transformation into a major rail hub. Streets leading down to Avenue d’Ouchy and Place de la Gare were integrated into a traffic system designed to efficiently link the city center to this new infrastructure. The station became a focal point not only for passengers but also for economic and commercial flows. However, unlike many other cities where the train station and its surrounding streets, such as Zurich’s Bahnhofstrasse, become vibrant urban hubs, Lausanne Gare has struggled to achieve the same level of integration and prominence. Despite its central location, the station often feels isolated and disconnected from the surrounding urban fabric.²⁰

This disconnection is deeply tied to Lausanne’s challenging topography. The station’s position in a natural depression, though functional for rail operations, limits its visual and spatial presence within the city. Streets like Avenue de la Gare primarily serve vehicular traffic, with limited pedestrian-friendly features or commercial vibrancy to create a strong sense of place. Additionally, the steep terrain surrounding the station isolates it from adjacent districts, reducing the potential for seamless integration with the rest of the city.

The construction of the M2 metro, while improving public transport accessibility, further complicates the possibility of transforming the station area. The M2 tunnel, which runs beneath the station and connects key points in the city, creates significant engineering constraints. In other Swiss cities, such as Zurich and Geneva, the CFF has been able to bury additional train lines to free up land for urban redevelopment above ground. In Lausanne, however, the presence of the M2 tunnel and the dense network of underground utilities and infrastructure make this option far more challenging. The vertical layering leaves little room for new subterranean developments, limiting the potential for the kind of large-scale, multi-use urban projects that have transformed station areas in other cities.

This constraint underscores the complexity of Lausanne’s relationship with its topography. While the M2 enhances connectivity across the city’s steep terrain, it also reduces flexibility for future railway expansions or urban redevelopment projects. The



Image: Tunnel with cables under the railway station, beuret.net, 2024.

result is a station that, despite its central role in the rail network, remains somewhat disconnected in urban terms. Efforts to densify and redevelop the area around the station are hindered by these technical and topographical constraints, making it difficult to free up surface land for ambitious urban projects. As a result, Lausanne Gare embodies both the opportunities and the limitations imposed by the city’s geography, where every intervention must balance technical, functional, and urban considerations.

The modernization of Lausanne’s railway station marks a turning point in the city’s urban history. By adapting to the demands of a rapidly expanding rail network, the station became not only a symbol of progress, but also a structuring element in Lausanne’s development. Even today, it remains a central point, integrating technical innovations while preserving its role as a crossroads between northern and southern Europe. This evolution testifies to Lausanne’s ability to transform the constraints of its terrain into assets for its economic and social development. Following the example of this sloping public space, it’s now intriguing to examine another site shaped by the city’s topography, such as the public square of La Riponne.



Image: Riponne square, Musée du Vieux-Genève, c. 1900.

LA RIPONNE

La Riponne's subsoil poses a number of challenges, with numerous networks running through its basement. La Riponne occupy a central place in the history and daily life of Lausanne. This space, located at the foot of the Cité, has undergone major transformations since its creation in the 19th century, evolving from simple market and gathering place to urban crossroads integrated into the modern transport network. Its evolution bears witness to Lausanne's ability to adapt its urban planning to its topography, while responding to the changing needs of its inhabitants.

Place de la Riponne, Lausanne's largest square, spans approximately 16,000 m², with a rectangular shape that measures roughly 130 m in length and 120 m in width, making it a significant public space in the city. Its design reflects an adaptation to the natural topography, situated on a plateau created by the vaulting of the Louve river and extensive infill work. The square serves as a flat, open area in a city otherwise defined by steep slopes and narrow streets.

The square's dimensions and elevation provide a striking contrast to the surrounding hilly terrain, offering a rare expanse of level ground in Lausanne's dense urban fabric. To the east, it is bordered by the Palais de Rumine, an imposing neo-Renaissance building perched slightly above the square, emphasizing the natural slope leading toward the city center. From the north to the south, the terrain slopes downward, making the square a key transitional space connecting higher and lower parts of Lausanne.

The underground infrastructure beneath Place de la Riponne is equally notable. A large underground parking lot, one of Lausanne's most heavily used, spans multiple levels beneath the square, accommodating the city's need for vehicular access without

Image: Riponne square, L. Polla, c. 1987.

compromising the square’s surface functionality. This underground space also integrates with the city’s public transport system, with direct connections to metro lines and bus routes.

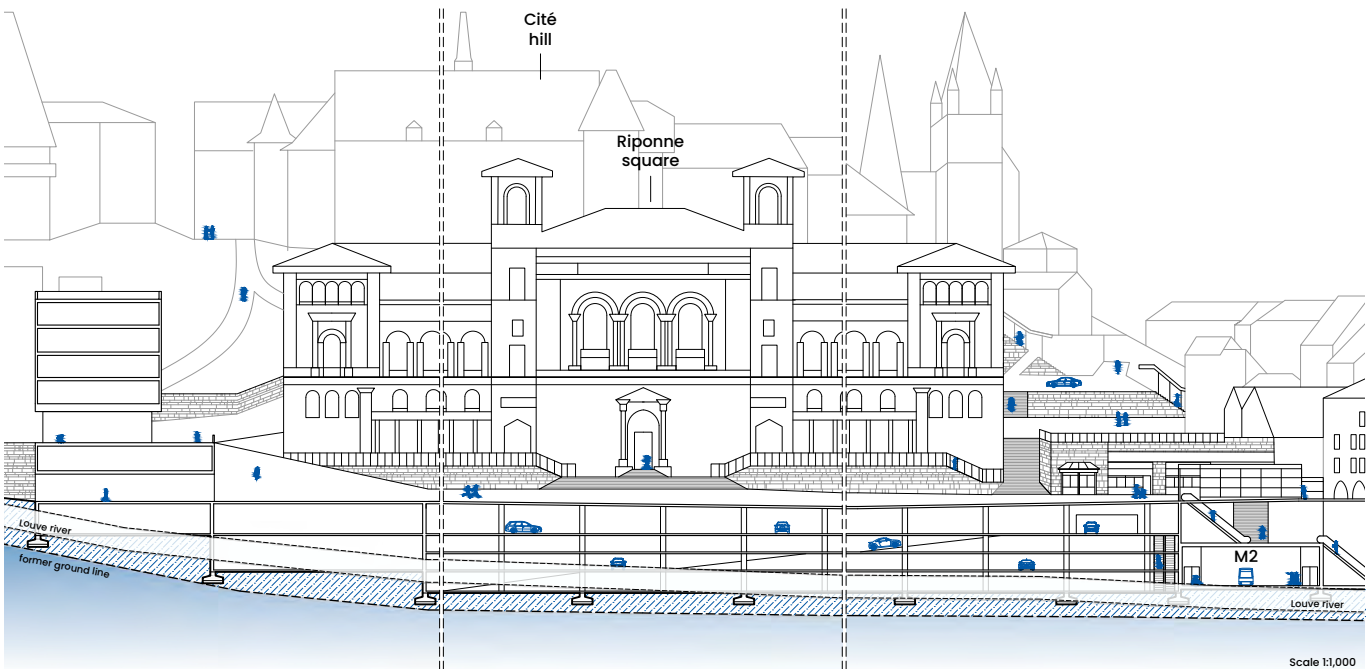
Place de la Riponne’s flat expanse and strategic location make it a focal point for civic activities, markets, and cultural events, transforming it from a utilitarian space into a vibrant urban hub as seen in the images p.53. Its creation demonstrates Lausanne’s ability to reimagine its topography, turning natural constraints into opportunities for modern urban design.

The place is the result of a process of urbanization that began in the late 18th century, when the city began to expand beyond its medieval walls. Integrated into the street network through projects such as the ceinture Pichard, it became a point of convergence between town and country. From the outset, it was home to dynamic commercial activities such as markets, livestock fairs and the timber trade. Over the years, it evolved into an open-air parking area, before undergoing a major transformation in the 1970s with the construction of an underground parking lot. This project, supported by downtown merchants, freed up the surface of the square, which was then redeveloped to accommodate pedestrian areas and a fountain.

At the same time, the Tunnel square is closely linked. It is conceived as a strategic crossroads as early as the 19th century, played a key role in the development of Lausanne’s transport system. Opened in 1862, the Rue du Tunnel links the historic heart of the city to its outskirts, facilitating the movement of goods and people. At the turn of the 20th century, the Tunnel became a hub for tramways, linking the rural hinterland with urban districts. This role as a transport hub was reinforced by the arrival of trolleybuses in the 1950s, before the m2, inaugurated in 2008 in La Riponne, once again transformed the dynamics of this area by reintegrating it into a modern mobility network.

These transformations are part of a broader vision of urban redevelopment, initiated in the mid-19th century with projects such as the Grand-Pont and the Barre tunnel. These infrastructures made it possible to tame Lausanne’s steep terrain, effectively linking the different parts of the city while redefining central spaces such as the Riponne and the Tunnel. However, these projects were not always without controversy. The construction of the underground parking lot at La Riponne in the 1970s, while freeing the area from cars, was criticized for the quality of the surface layout, which was perceived as pedestrian-unfriendly. Similarly, the transformations of the Tunnel, which saw its role as a market declining in favor of car parking, illustrate the tensions between functional needs and aspirations for more convivial public spaces.

The history of these two squares is marked by recurring proposals



Section: Riponne square.

²¹ M. Jaquet, “Riponne/Tunnel: Lausanne entre Deux Places”.

to improve their integration into the urban fabric. As early as 1905, projects imagined the Riponne as a public garden, with lawns, water features and shrubs, while the market would be moved under a large canopy to the Place du Tunnel. These ideas, although only partially realized, reflect a constant desire to make these spaces more welcoming and aesthetically pleasing. More recently, various thesis projects from EPFL has proposed raising the level of the Riponne in whole or in part to better connect it to its surroundings, underlining the importance of these squares in Lausanne’s landscape.²¹

The section of Riponne Square illustrates the multi-layered urban fabric, shaped by the topography. Below the surface, the Louve river, now channeled underground, runs beneath the square, highlighting Lausanne’s long-standing efforts to adapt its natural waterways for urban development. Additionally, the underground levels accommodate parking areas, easing congestion in the city’s dense core. The M2 metro line, situated at a deeper layer, provides seamless connectivity while minimizing surface disruptions.

Today, La Riponne and the Tunnel continue to play a central role in Lausanne’s life. Although their appearance and functions have evolved, they remain meeting places, attracting residents and visitors alike thanks to their accessibility and emblematic character. Their transformation, driven by economic, social and aesthetic needs, reflects the history of a city in constant adaptation, capable of combining tradition and modernity in a context of unique topographical constraints. In this way, La Riponne shows its versatility as a place caught up in its relief, and allows us to draw a conclusion about the city’s development in relation to its difficult topography.



Image: The former fish market, Musée de l'Ancien Evêché, c. 1865.



Image: The Centrale Street, L. Polla, c. 1987.

CONCLUSION

The city of Lausanne, situated on a unique and challenging topography shaped by steep slopes, moraines, and valleys, has demonstrated remarkable ingenuity in adapting its urban form to its natural terrain. This thesis has explored the ways in which Lausanne's relief has influenced its development through three primary networks: rivers, roads, and railways. It has also sought to analyze the interaction between the surface and subsoil layers of the city, emphasizing the importance of integrating these two dimensions for more effective and sustainable urban planning.

Lausanne's landscape was initially shaped by the retreat of the Rhône Glacier, which left behind prominent moraines such as Montbenon and Montriond and created the valleys of the Flon and the Louve. These geographical features provided a natural framework for the city's development. During the medieval period, the city concentrated its growth on three key hills - Cité, Le Bourg, and Saint-Laurent - where settlement was advantageous due to the defensive benefits and strategic positioning of elevated terrain. However, as the city expanded, the valleys and rivers became obstacles that needed to be navigated and adapted to meet the needs of a growing population.

One of the most significant transformations was the vaulting of the Flon and Louve rivers. Originally exposed and central to the urban landscape, these waterways were redirected underground to prevent flooding, improve sanitation, and reclaim surface space for urban development. This intervention not only addressed practical challenges but also enabled the creation of vibrant new areas in the heart of the city. For example, Pépinet Square, Riponne Square, and the Flon district were all made possible by the vaulting of these rivers. Over time, these spaces evolved to serve a variety of

functions: Riponne became a hub for social gatherings, while the Flon transitioned from an industrial zone to a modern mixed-use district.

The relief of Lausanne also necessitated the development of extensive connective infrastructure to bridge the divides between its fragmented hills and valleys. Bridges such as the Grand-Pont, Bessières, and Chauderon, along with tunnels like the Barre, were constructed to facilitate movement across the city. These structures allowed Lausanne to overcome its topographical challenges and unify its various districts. The integration of rail infrastructure further highlights the city's innovative approach to its terrain. While the main railway station was strategically placed on relatively flat terrain to accommodate the gentle gradients required by trains, the steeper areas of the city were served by innovative transport systems. The M2 metro, designed to navigate the city's slopes, and the LEB train, which connects Lausanne to its surrounding regions, exemplify the city's ability to leverage modern technology to enhance mobility across its difficult terrain.

The subsoil of Lausanne has been instrumental in these developments. Underground spaces have been utilized not only for transport but also for essential services such as waste management. The Tridel tunnel, for instance, transports waste to the incineration plant without adding to the city's surface traffic congestion, showcasing the potential of underground networks to alleviate urban pressures. Additionally, parking structures like those at Montbenon and Riponne demonstrate how the subsoil can be used for practical purposes while preserving the surface for public spaces. These dual-use solutions reflect a broader strategy to optimize the limited space available in a dense and topographically complex city.

This thesis has highlighted the critical role of Lausanne's subsoil as a resource for urban development. Beneath the city's streets lie a dense network of rivers, drainage systems, the metro line, rail tunnels, and other essential infrastructure. This interconnectedness has enabled Lausanne to thrive despite its challenging terrain. However, it also presents significant constraints, particularly as urban expansion increases demand on these underground systems. The expansion of the main railway station illustrates this complexity, where old postal tunnels, the metro system, and rail cable conduits intersect, complicating further development. Addressing these challenges requires a comprehensive understanding of the subsoil and a coordinated approach to its planning and use.

While this research provides valuable insights into Lausanne's urban evolution, it is not exhaustive. Certain aspects of the subsoil, such as reservoirs, atomic shelters, and heating and electrical systems, were beyond the scope of this study. Future research could delve



Image: Construction of the M2 tunnel in La Riponne, c. 2004.

deeper into these elements, exploring how they contribute to the city's functionality and resilience. Furthermore, this study raises questions about how Lausanne's strategies can be applied to other cities with similar topographical challenges. In an era of urban densification and climate change, understanding how to harmonize surface and subsoil systems will be crucial for creating sustainable and livable urban environments.

A key lesson from Lausanne is the importance of integrating underground networks into urban planning, not as an afterthought but as a core consideration. This integration can help alleviate surface congestion, optimize land use, and create more resilient cities. For example, the dual use of the Tridel tunnel and Louve network demonstrates how existing infrastructure can be repurposed to meet new challenges. Similarly, the successful adaptation of the city's transport networks - such as the tramway, later replaced by the pneumatic metro - shows how innovation can transform constraints into opportunities.

Ultimately, Lausanne serves as a model for how a city can adapt to its relief and turn natural challenges into strengths. By embracing its topography and integrating innovative solutions, Lausanne has not only preserved its identity but also positioned itself as a resilient and dynamic urban environment. Its ability to harmonize surface and subsoil systems is a testament to the power of thoughtful urban planning, offering valuable insights for cities worldwide that face similar geographical constraints.

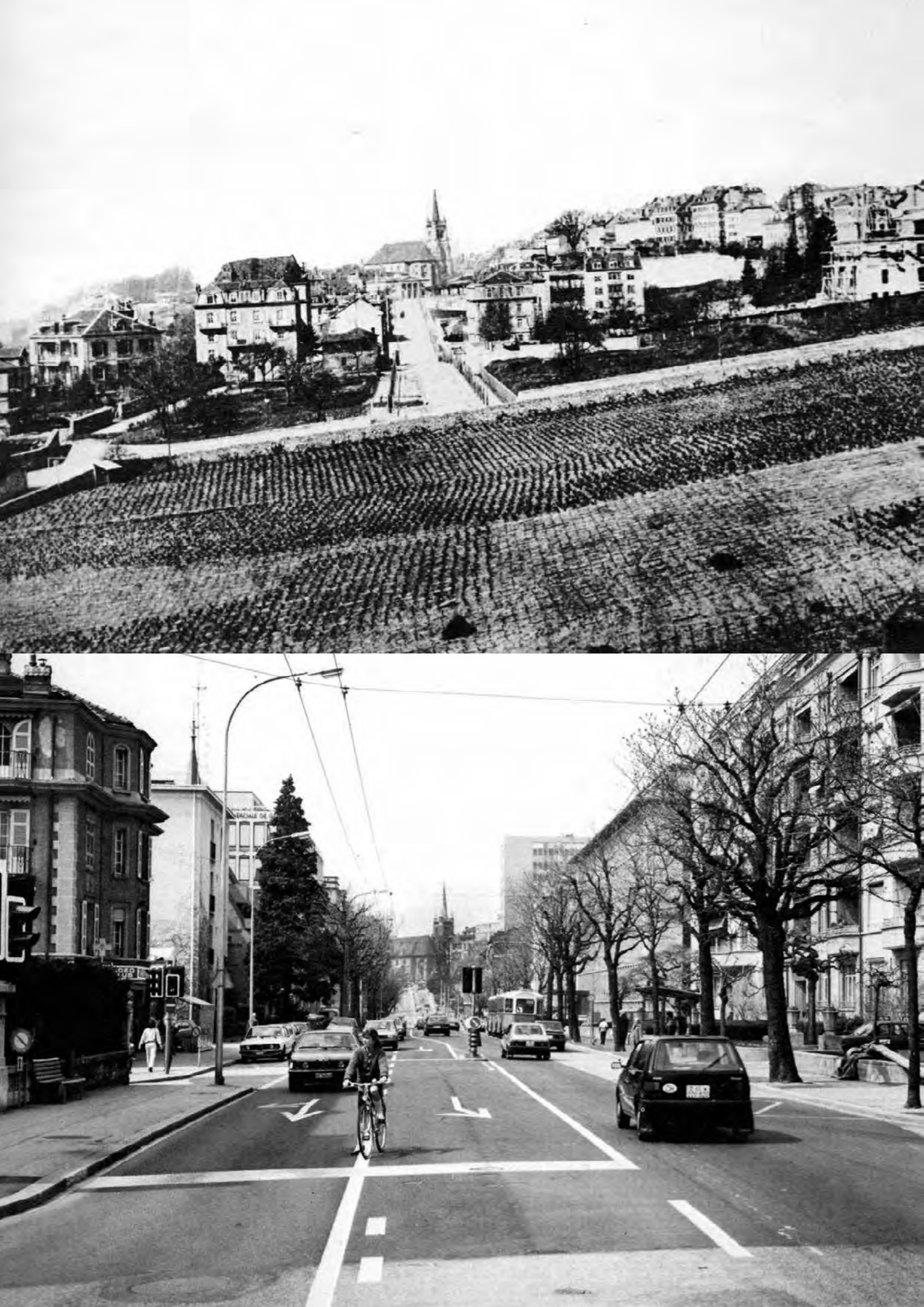


Image: Saint-François, Musée de l'Elysée, c. 1900.

Image: Saint-François, L. Polla, c. 1987.

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Up In Relief The City of Lausanne Down

Set between the shores of Léman lake and hills shaped by the retreat of the Rhône glacier, Lausanne's steep topography of moraines, valleys, and slopes has profoundly influenced its urban development. This study delves into how the city has adapted to these natural constraints by transforming them into opportunities through innovative solutions.

Through an in-depth exploration of three key networks - rivers, roads, and railways - it examines the city's evolution from its medieval settlement on three iconic hills to its modern urban fabric. The Louve and Flon rivers, vaulted to prevent flooding and reclaim space, made possible the creation of vibrant areas such as the Flon district and Riponne Square. Bridges like the Grand-Pont and Bessières, and tunnels such as the Barre, highlight Lausanne's

ability to connect fragmented terrain, while the development of metro systems and underground infrastructure demonstrates how the subsoil has been leveraged to optimize urban functionality.

This book sheds light on the hidden layers beneath Lausanne - rivers, parking structures, metro lines, and waste tunnels - and how they interact with the surface. It argues for the importance of integrating underground spaces into urban planning, not only as a solution to surface congestion but as a vital element of sustainable and innovative development.

Lausanne serves as a powerful example of how a city can embrace its natural landscape to build a resilient, functional, and forward-thinking urban identity.

Image: Underground construction works for the Riponne parking lot
Musée historique Lausanne, 1972.