Of Water and Matter

A Material Practice for Post-Extractive Landscapes content

abstract

In the post-extraction landscapes of the Rheinisches Braunkohlerevier, the relationship between water and matter no longer follows natural rhythms—it is charged, reactive, and unfolding. Here, contamination is not a singular event but a condition that accumulates, binds, weathers, and seeps across geological and temporal scales. Conventional restoration frameworks respond with binary visions of compensation and separation. This thesis takes a different approach—remaining within the unsettled terrain, it traces the transformations already in motion.

Water, long drained to make space for mining, returns to a stratigraphy fractured and unsettled by decades of extraction. It moves through disrupted sediments, activating chemical reactions that carry heavy metals and acidity through soil, into groundwater, and toward the surface. Matter does not passively receive these flows; it absorbs, resists, and transforms them. This interaction forms the foundation of the thesis: a material practice rooted in territorial specificity, where design engages the dialogue between dissolution and deposition, contamination and gradual reconfiguration.

By reworking site-bound matter, the project proposes infrastructural prototypes that respond to their environment not through resistance, but through participation. Each intervention is situated, embedded in cycles of absorption, stasis, and release. Rather than proposing resolution, the thesis offers a framework for ongoing negotiation—where design operates within, rather than above, the entangled realities of water and matter.

Fig. 1: Neurath Powerplant

CONTEXT

situating the extraction landscape

Fig. 2: Garzweiler Mine

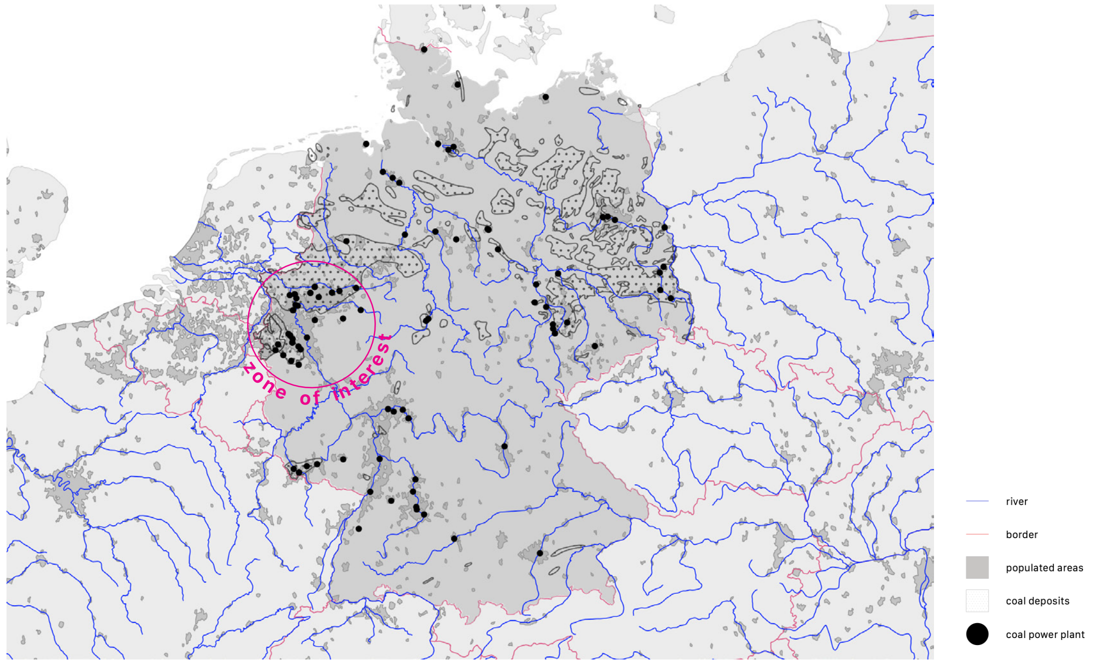


Fig. 3: Rivers and Powerplants

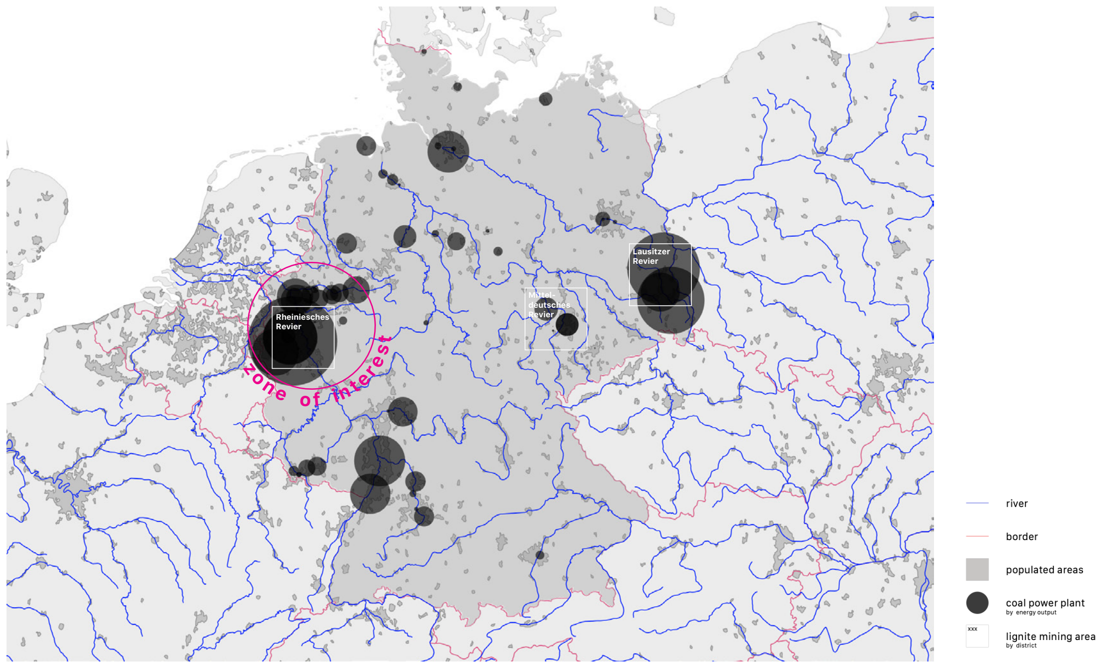


Fig. 4: Germany's Energy Hubs

CONTEXT

The post-mining landscapes of the Rhineland, located in western Germany between Cologne, Aachen, and Mönchengladbach, reflect a region where extraction has extended far beyond the removal of lignite. Over decades of open-pit mining, geological strata have been displaced, groundwater drained, ecologies fragmented, and villages erased. What remains is not a blank slate, but a terrain structured by disruptance and afterlife—a site where material, hydrological, and legal systems continue to act and react.

This thesis begins from the recognition that contamination is not a momentary disturbance but an ongoing condition embedded in the landscape.

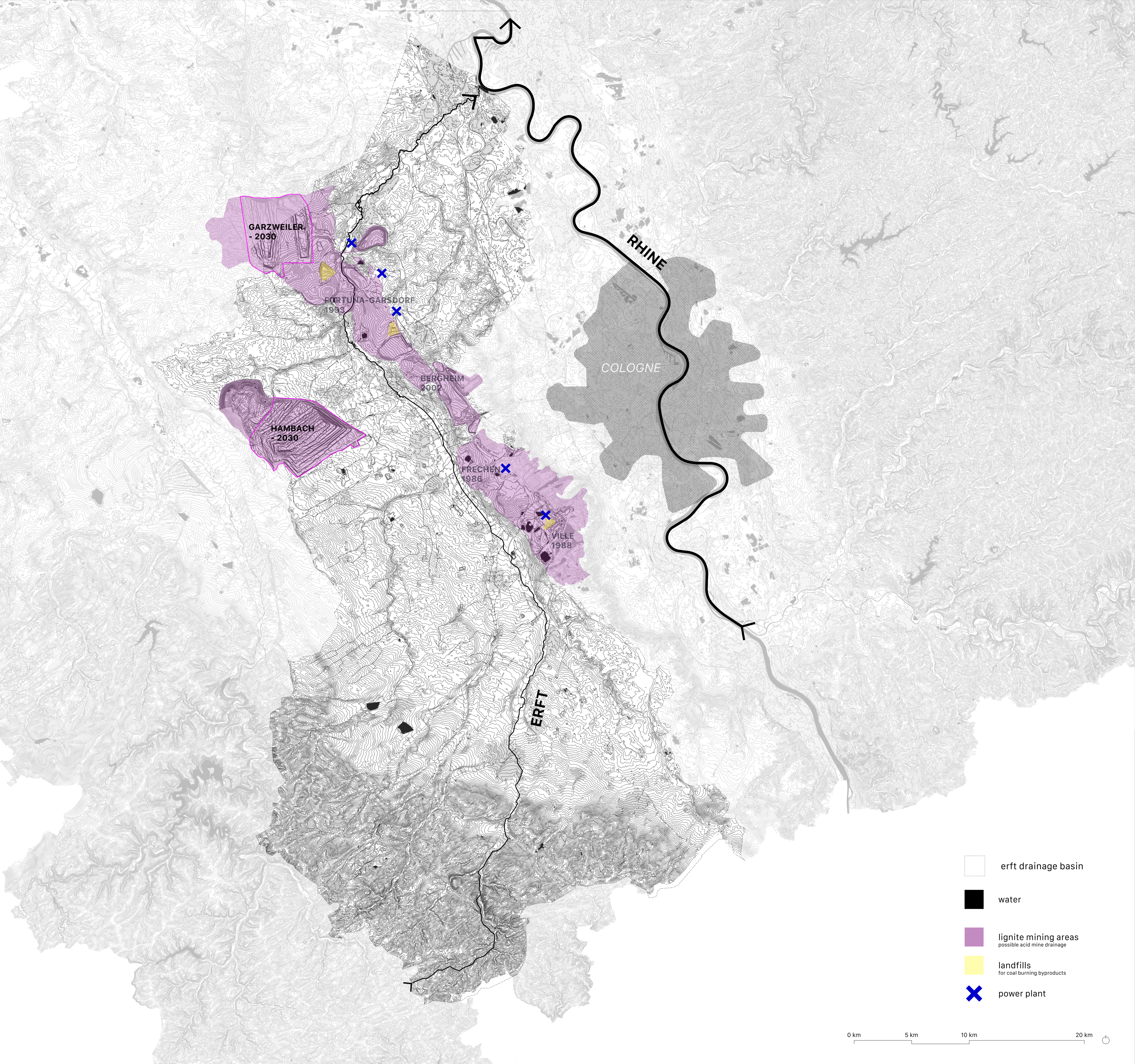
As Anna Tsing writes, „Contamination creates forests, transforming them in the process. Because of this, noticing as well as counting is required to know the landscape" (Tsing, 2017, p. 30). Contamination is not merely an outcome of extraction; it is a shaping force that continues to generate change altering not only ecological systems but also the methods through which we must learn to perceive them. This thesis approaches the post-mining territory not as a static aftermath, but as a site where new ecologies, chemistries, and spatial conditions emerge from ongoing entanglement. To understand this landscape, one must trace how contamination persists, circulates, and reorganizes matter over time—requiring both observation and responsiveness to shifting conditions. In this view, the affected environment is not a closed system in need of repair, but an open-ended process of transformation in which architectural and ecological practice must continuously adapt.

Water is one carrier of this condition, moving vertically and laterally through fractured soils and oxidized minerals. *Matter*—both as extracted resource and residual substance—responds to this transformation, leaving traces that shape future interactions and embed history into the evolving material condition of the site.

The effects of mining persist through disrupted flows, altered chemistries, and engineered ecologies. As groundwater begins to rebound with the cessation of lignite mining by 2030, it does not return to a familiar environment. It meets a restructured geology—mixed layers of loosened sediments. These encounters trigger chemical reactions, releasing metals and acidity into surrounding systems. The contamination that results is not isolated—it moves, accumulates, and interacts across time and scale triggering a ripple effect of uncertainties.

THE ERFT RIVER BASIN

Fig. 5

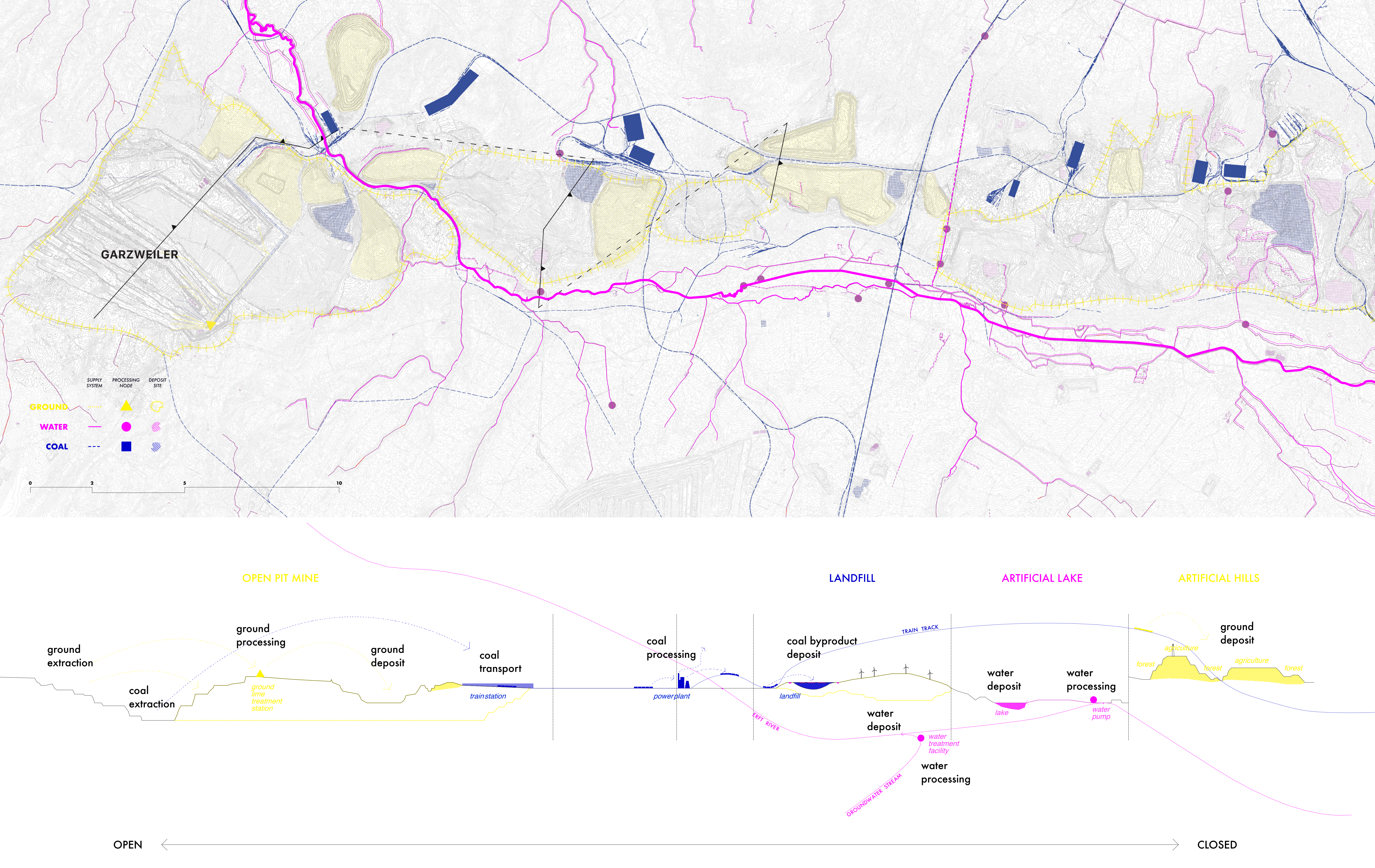


The Erft River, flowing for approximately 106 kilometers, originates in the Eifel region and winds its way north through western Germany before joining the Rhine near Neuss. Once a meandering river known for its quiet presence, the Erft has been heavily shaped by centuries of human intervention—diverted, straightened, and canalized to suit agricultural expansion and industrial operations. Its basin has played a central role in supporting and absorbing the impacts of lignite mining across the Rhineland.

Within its catchment area lie the active Hambach and Garzweiler mines, as well as the former Frechen, Fortuna-Garsdorf, and Bergheim mines. These operations have not only redefined the hydrological map of the region but have also transformed the river's role—from a passive waterway to an active agent in the circulation of altered ecologies, groundwater recovery, and contamination spread. As the lignite industry phases out and groundwater is allowed to rise, the Erft basin becomes a space of renewed complexity: at once recovering, reacting, and reorganizing. It is no longer a background condition, but a terrain where water and matter continue to move together.

FLOWS AND INFRASTRUCTURES

Fig. 6



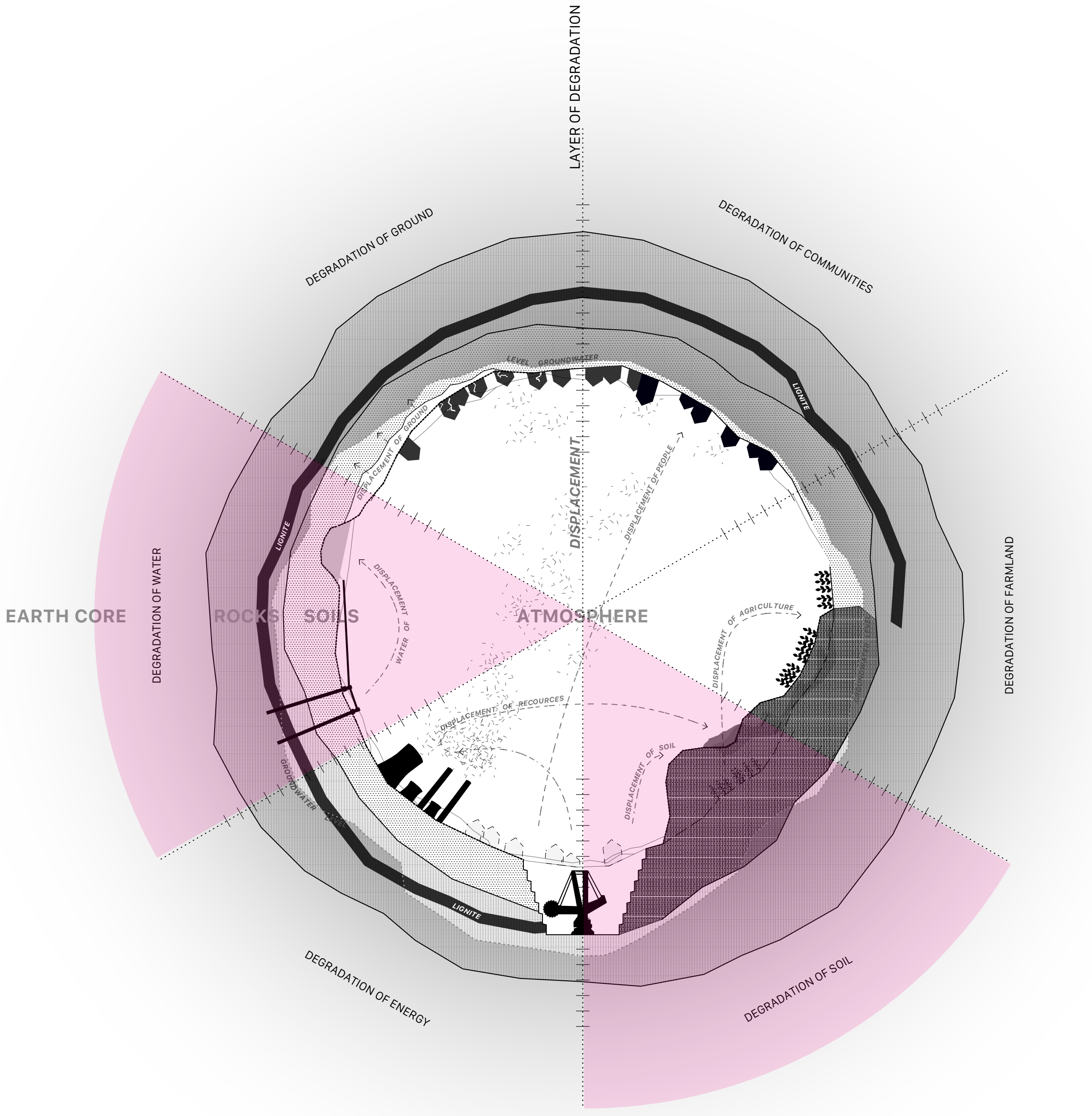


Fig. 7: Displacement and Degradation

The research started by recording these movement of matter (coal and soil) and water throughout the region and in relation to the mining industry. The displacement of these materials can be connected to consequences of degradation spatially and temporally disconnected from the cause.

These dispersed flows of water and minerals blur the boundaries between event and aftermath, cause and symptom.

They demand a spatial rethinking that goes beyond conventional boundaries and toward a topology of entanglement, where hydrological, material, and regulatory flows continuously reshape the terrain. This shift in perspective lays the groundwork for examining how topological thinking can help make sense of these dispersed, interacting systems—where flows do not follow linear paths but fold into and through landscapes, institutions, and bodies alike.

Fig. 8: Soil Conveyor Belts in the Mining Pits

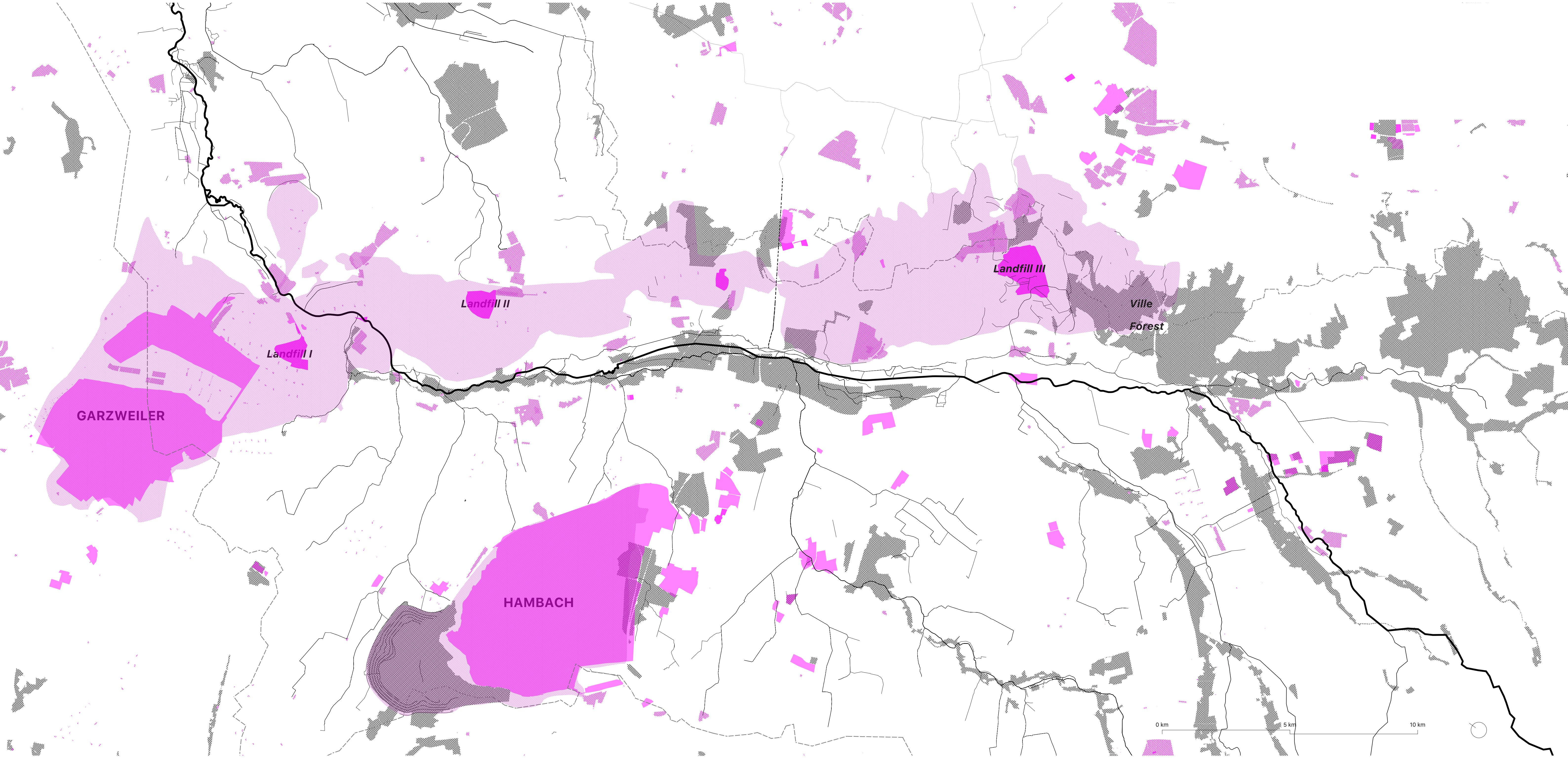
Fig. 9: Groundwater Pumping Station

TOPOLOGY

rigid binaries in a fluid territory

Fig. 10: Industry / Nature Protection

INDUSTRY AND
‚AUSGLEICHSFLÄCHEN'
Fig. 11



water

nature protected zones

lignite mining areas
possible acid mine drainage

active industrial zones

TOPOLOGY

Building on the understanding that contamination is a continuous condition embedded in the landscape, this section turns to the spatial and legal frameworks that shape how such landscapes are commonly treated in Germany—revealing an underlying separation: the conceptual divide between human and non-human actors. This binary is evident in the rigid distinction between isolated, idealized nature-protected zones and the highly extractive operations that dominate surrounding areas. While this framing reflects the dominant approach to managing these landscapes, it risks oversimplifying the dynamic and fluid relationships that define such environments. This research challenges the rigidity of this framework, advocating for a perspective that embraces fluidity and less-defined interactions. Essentially, it establishes that all actors within our environment are inseparably interconnected within one big mesh, constantly rearranging in feedback loops.

This rigidity is not only conceptual—it is also institutionalized. In Germany, the legal apparatus governing ecological restoration enforces a technical logic of equivalence and spatial offsetting. §15 of the Federal Nature Conservation Act (Bundesnaturschutzgesetz) dictates that interventions in nature must either be avoided or offset through compensation measures known as *Ausgleichsflächen*. In theory, this is a progressive law: it seeks to embed environmental concerns into spatial development. But in practice, it often reduces ecological processes to accounting operations. One hectare disturbed here, one hectare „restored" there—often far away or unrelated to the affected systems.

This system is deeply spatial in its thinking, and paradoxically, deeply aspatial in its ecological sensitivity. It renders nature into discrete, measurable parcels that can be legally and economically quantified, separated from the dynamic systems they operate within.

As a result, the law does not intervene in the entanglements that cause degradation; it simply shifts the consequences elsewhere. By separating sites of extraction from sites of compensation, §15 reinforces a logic of detachment and fragmentation.

These offset measures tend to favor superficial markers of biodiversity, habitat type, or vegetative cover. They fail to account for the chemical, hydrological, and temporal dimensions of disruption. As Anna Tsing notes, "disturbance-based ecologies" are not easily stabilized by human ideals of order (Tsing 2017). They are contingent, adaptive, and often incomplete. Yet the current policy language frames nature as a patient to be cured, a balance sheet to be recalibrated.

§ 15 Federal Nature Conservation Act

Compensation and Replacement Measures (Condensed)

(1) Avoiding interventions
Interventions in nature and the landscape should be avoided or minimized as much as possible.

(2) Compensation and replacement measures
Unavoidable impacts must be compensated through compensation measures (restoring the affected functions) or replacement measures (equivalent ecological improvements).

(3) Compensatory payment
If compensation or replacement measures are not possible, a compensatory payment must be made, which is earmarked for nature conservation and landscape management measures.

Terms like repair, restoration, resilience, and revitalization are central to this logic. They assume a prior condition of harmony, and more problematically, imply that human interventions can reinstate it. In mining territories, however, the past is not only unrecoverable—it is part of the contamination itself. As Donna Haraway suggests, "staying with the trouble" means resisting the fantasy of redemption, and instead committing to ongoing care within damaged worlds (Haraway 2016).
This legal framework also reveals a hidden aestheticization. Restoration is often interpreted visually—can a place "look" natural?—and regulated accordingly. But landscapes are not only visual; they are also chemical, temporal, and infrastructural. Restoration measures that rely on planting native grasses or creating wetlands on the surface rarely address the underlying dynamics of contamination that continue underground or in groundwater systems.

Timothy Morton's concept of hyperobjects—entities so vast in time and space that they cannot be fully grasped—forces us to confront the non-linear consequences of contamination (Morton 2013). The changes in regional hydrology, the heavy metals in groundwater, the displaced strata—all persist and interact long after extraction ends. In this sense, the ecological harm is not bounded. It leaks, mutates, accumulates. A singular act of destruction becomes a long event, unfolding across generations and infrastructures.

To "restore" such a site by surface intervention, is to ignore its entangled nature.

This language of return is embedded in the state-driven environmental governance models of the European Union as well. Terms like "net ecological gain" or "no net loss" obscure the complex relationships that landscapes contain, reducing them to input-output systems. In doing so, they reinforce anthropocentric hierarchies and treat ecological complexity as a matter of statistical compensation.

By exposing the gaps between policy language, ecological processes, and geological conditions, this thesis argues that current restoration approaches are insufficient. What is needed is a new language of cohabitation, symbiosis, and ongoing adaptation. Rather than seeking to „restore nature" in an effort to undo contamination, any intervention should begin with its presence—its agencies, its durations, and its affordances.
In this light, the architectural project should no longer acts as a shield from damage but become an interface within it. It should acknowledge that the landscape is not a container to be fixed, but a participant in a system that exceeds design.

Fig. 12: Satellite Image of the Zieselsmaarsee, in a Post-Mining Area

In the southern mining region where groundwater started rising again, there are already signs of this underlying issue. The protected forest around the red Zieselsmaarsee was artificially planted and is dependent on external input, yet it is a protected area. This protection and idealization hold this area in a static state, very much in control through human influence. The dichotomous condition of degradation and idealized nature in parallel reoccurs throughout the area reinforcing a specific, controlled ecological state, disabling adaptation.

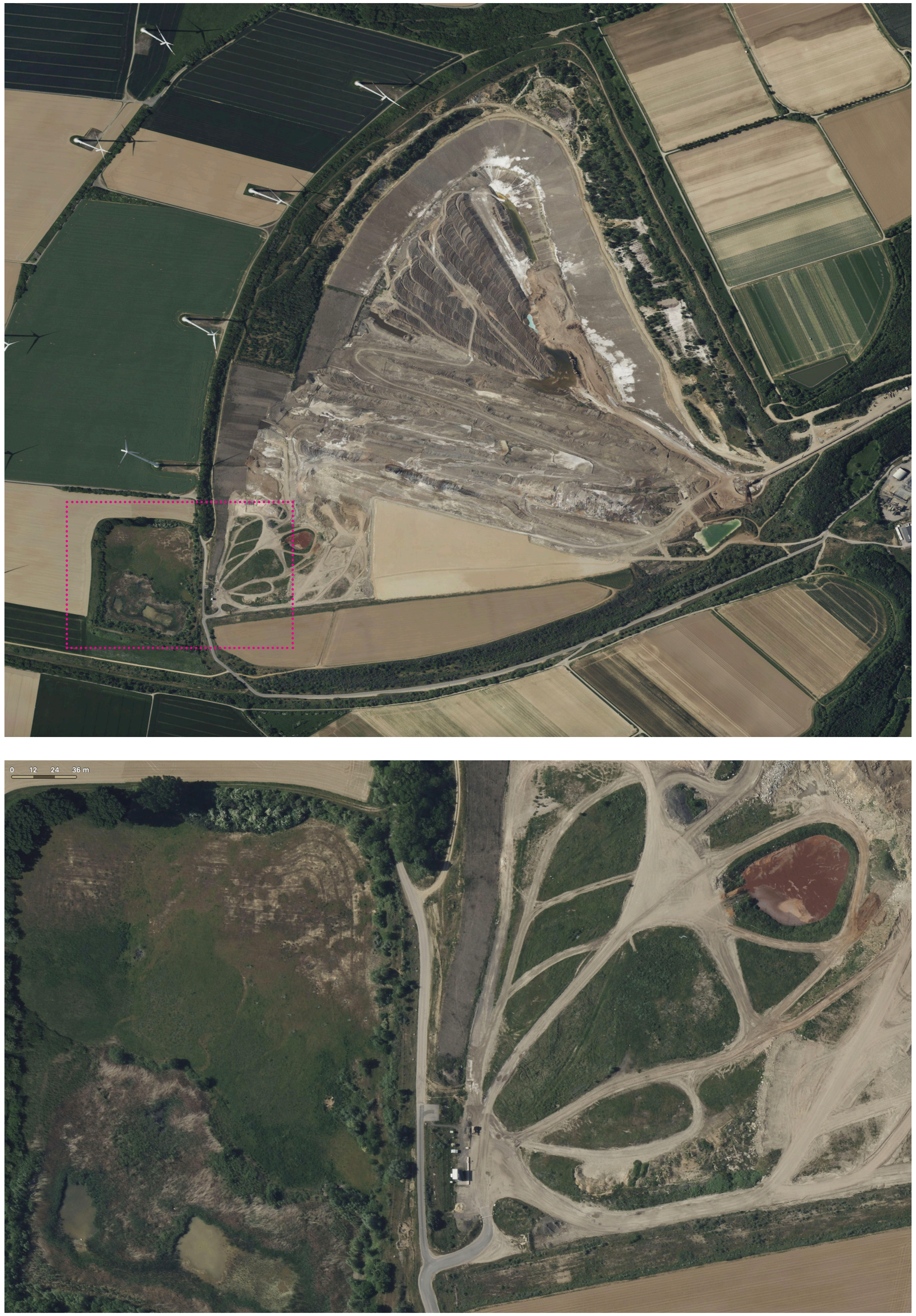


Fig. 13: Landfill and adjacent Biotope

Next to the landfill, which covers approximately 1.3 km², a biotope of just 0.066 km² has been designated. Rather than forming a coherent ecological area, the protected land is limited to a narrow 150-meter-wide strip surrounding the landfill. This fragmented and minimal intervention, though labeled as nature protection, appears more like a buffer zone aimed at preventing toxic runoff from reaching the surrounding agricultural land than a serious attempt at ecological restoration or habitat creation.

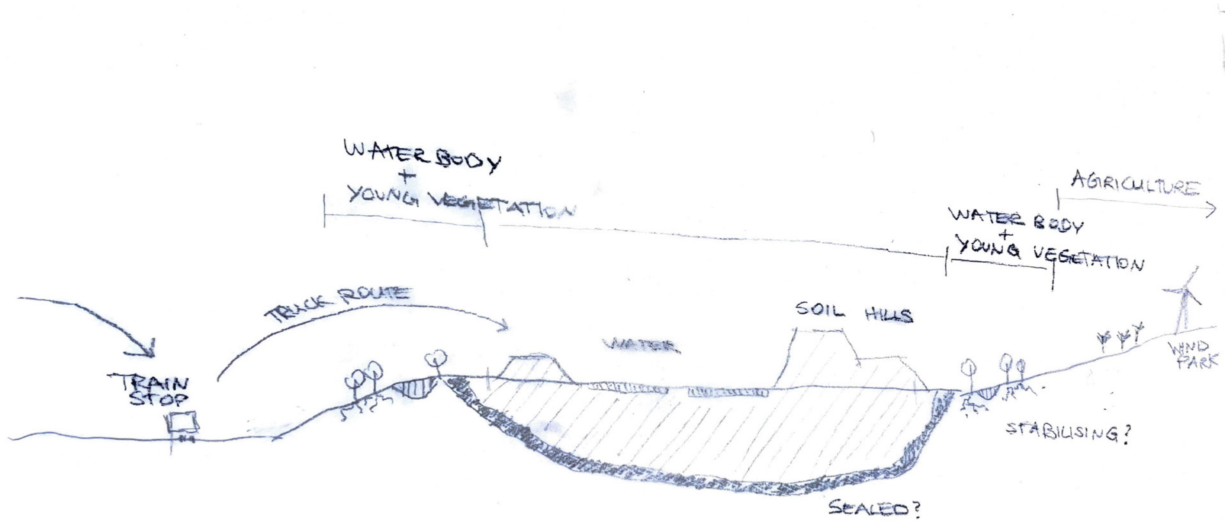


Fig. 14: Spatial Sequence of a Landfill

The emergence of repair, restoration, and nature protection as spatial practices can be traced back to the Industrial Revolution, when the visible degradation of landscapes triggered a countermovement seeking to reverse or mitigate its effects. These efforts reflected a desire to re-establish control or balance in the face of an accelerating transformation of nature. However, this framing positions nature and industry as oppositional forces, when in reality, they have always co-evolved. What we now call landscape is the product of hybrid processes—simultaneously natural and engineered.

The German term Kulturlandschaft, often mistranslated as „cultural landscape," more accurately refers to this co-productive relationship. It denotes a landscape shaped by human activity, but not necessarily at the expense of ecological function. In earlier iterations, such cultivated spaces allowed for mutual benefit: agricultural production occurred alongside increased biodiversity. However, in the current moment, this relationship has hardened into a regime of mechanical intervention aimed at optimizing predictability. The straightening of rivers, construction of weirs, and calibration of flow rates reflect a mode of control that allows little space for adaptability. In a context of contamination, this rigidity risks becoming even more entrenched.

Donna Haraway's concept of sympoiesis—literally, „making-with"—offers a more generative model (Haraway 2016). Unlike systems that are self-contained (autopoietic), sympoietic systems depend on open-ended collaboration, co-dependence, and feedback. Applying this lens to the river and its adjacent landscapes allows for a reframing: rather than treating contamination as a problem to be removed, it becomes a condition to navigate collaboratively. For such a system to function, it must be responsive, not just regulated. It must allow for change, iteration, and uncertain outcomes.

While the landfill serves as a clear example of the spatial logic underpinning environmental management—one of fragmentation, delineation, and surface-level mitigation—the river challenges this framework.

It cannot be easily enclosed or stabilized; it flows through, across, and beneath these spatial strategies.

It became central to this project not only due to its role in the extractive processes and the circulation of pollutants, but also because it reveals the limitations of compartmentalized approaches. The river thus shifts the conversation from land management to fluid systems, from isolated interventions to ongoing interdependencies—offering a more generative ground for spatial and architectural engagement. In this sense, the river is not only a conduit for contamination, but a testing ground for sympoietic thinking—where human and non-human agencies participate in shaping the environmen in a symbiotic relationship.

Once shaped by mutual adaptation between ecological cycles and human practices as a Kulturlandschaft, the river now embodies a form of ‚neo-nature'—a hybrid condition that is technically controlled yet ecologically fragile. This transformation from cultivated floodplain to engineered channel represents the broader tension between control and adaptation. As such, the river becomes both a witness to past interventions and a medium through which new, responsive modes of cohabitation can be tested, offering a pathway to reconceive restoration not as a return, but as an open-ended, situated process.

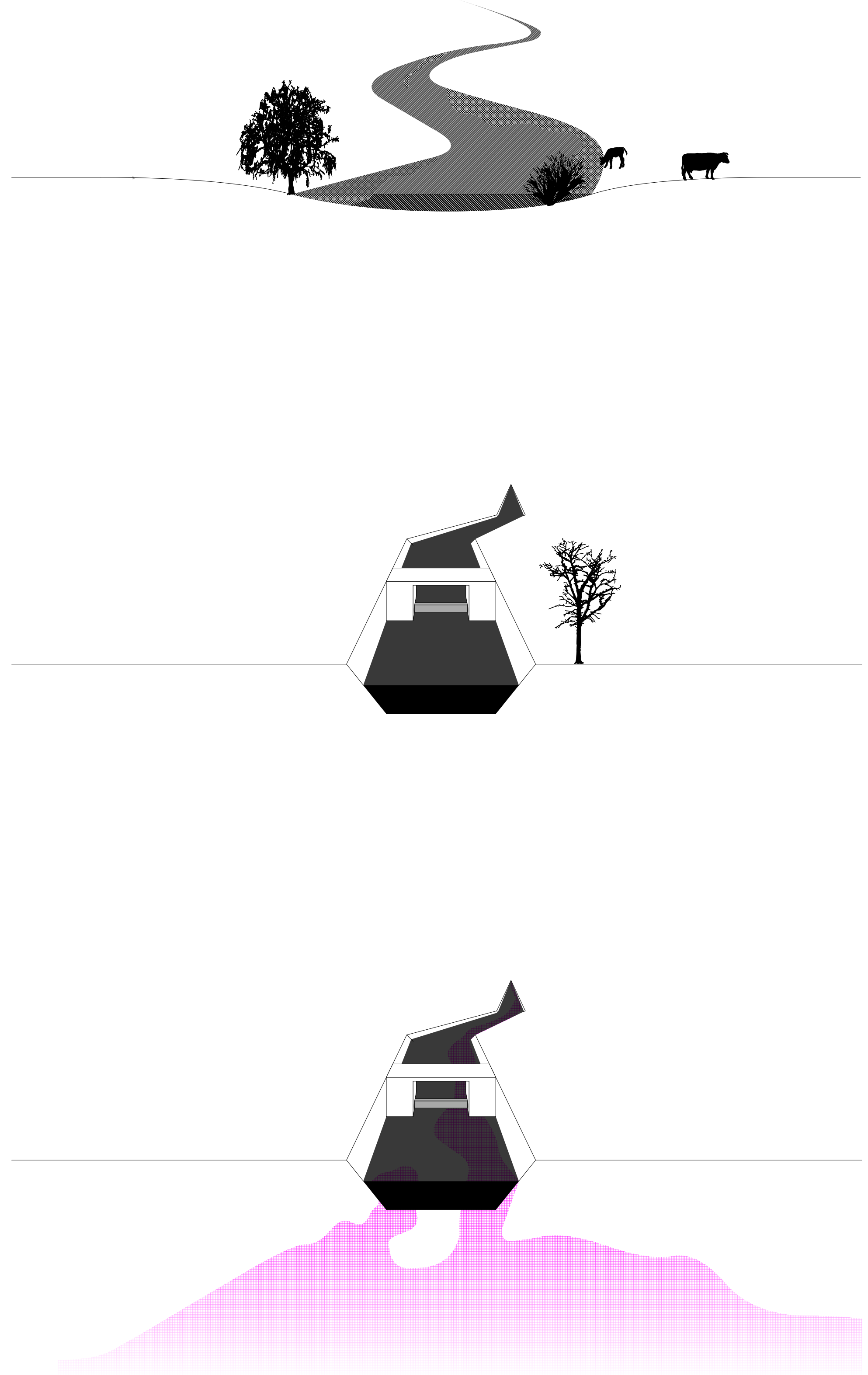


Fig. 15: from Kulturlandschaft to Neo Nature

TRANSFORMED RIVER

Fig. 16: Management of the Flooding Zone, 1910

Historically, the river itself has been significantly altered in an effort to control its natural seasonal floodings. Areas once defined by swamps and ‚Benden'—a German term referring to low-lying floodplain meadows along the riverbank historically used for grazing and known for their capacity to absorb seasonal floodwaters—acted as natural buffers, absorbing excess water during periods of high flow. Over time, these landscapes were replaced by canalised channels and extensive weir systems in an attempt to impose order and predictability. However, this attempt at control was ultimately overshadowed by the needs of lignite mining: large-scale groundwater pumping drained the surrounding area, reducing the water table and transforming the floodplain into arable and buildable land. This shift allowed for expanded settlement along the river, a transformation clearly visible when comparing Prussian maps from 1836–1850 with current cartographic records. Despite these interventions, the unpredictability of water remains; the catastrophic flooding in 2021 severely damaged the villages of Blessem and Frauenthal, underscoring the limits of engineered stability in a dynamic system.

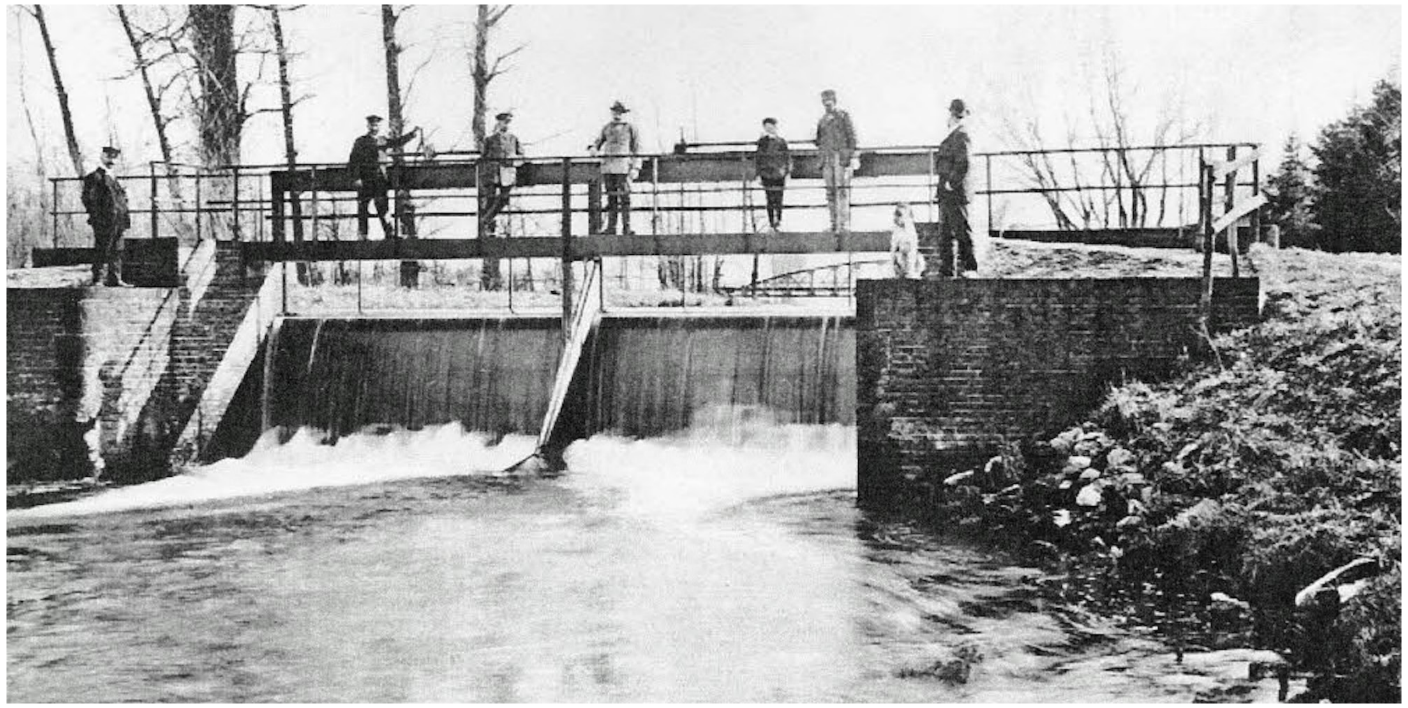
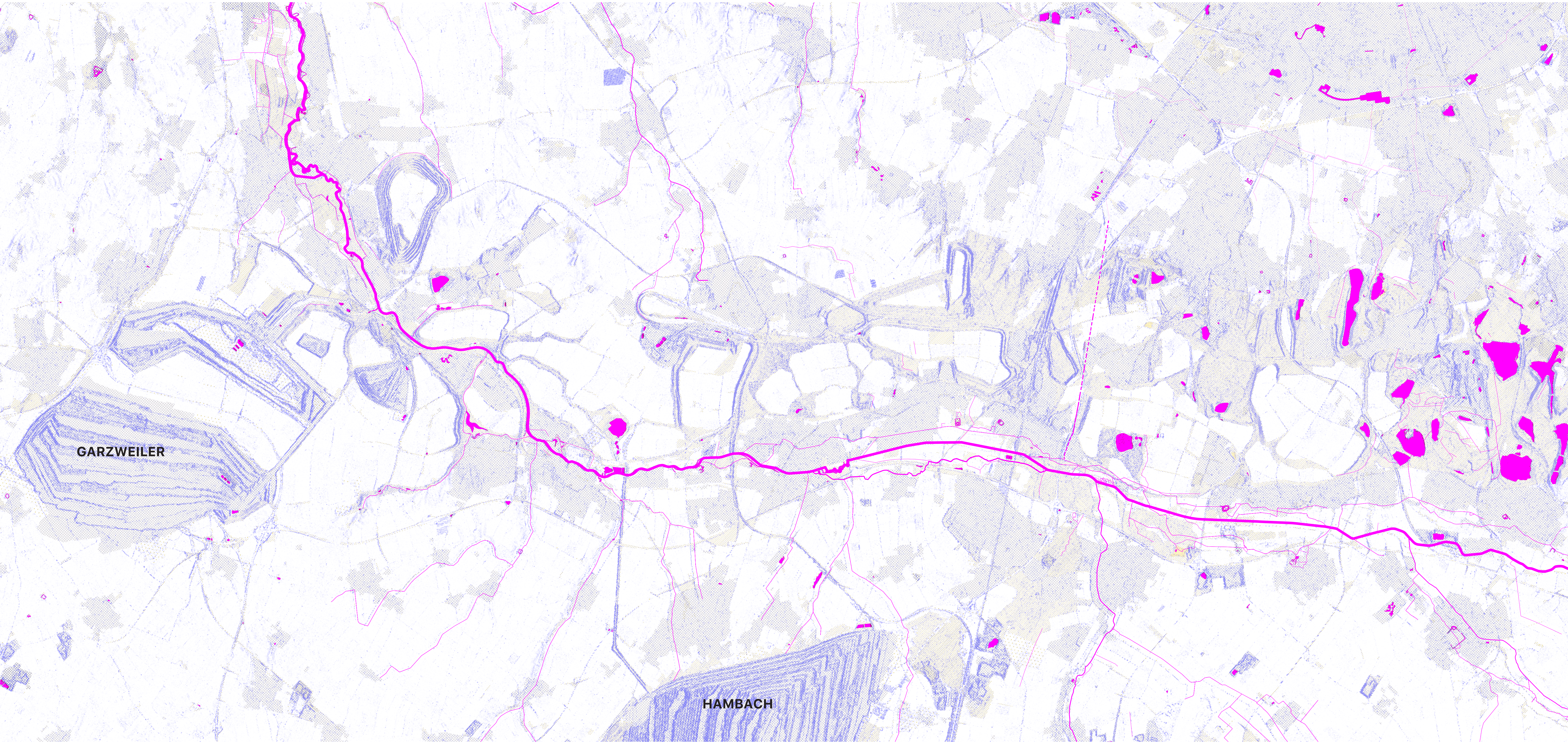


Fig. 17: Introduction of Weir System on the Erft in Zieverich, 1909

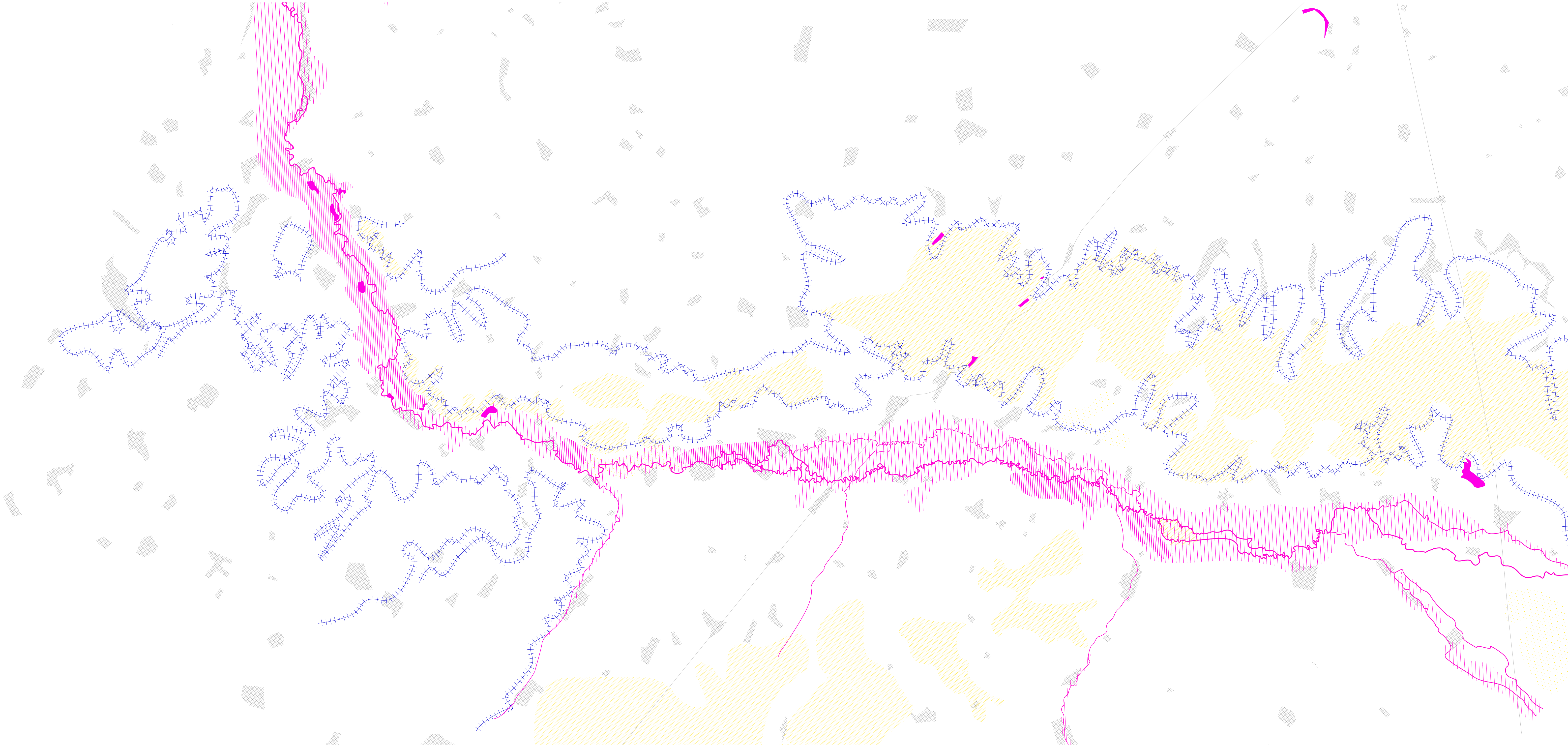
Fig. 18: Erosion in Blessem during the flood disaster in summer 2021



2024

0 km 5 km 10 km

VEGETATION
WATER
TERRAIN
SETTLEMENTS
Fig. 19



1836 – 1850

0 km 5 km 10 km

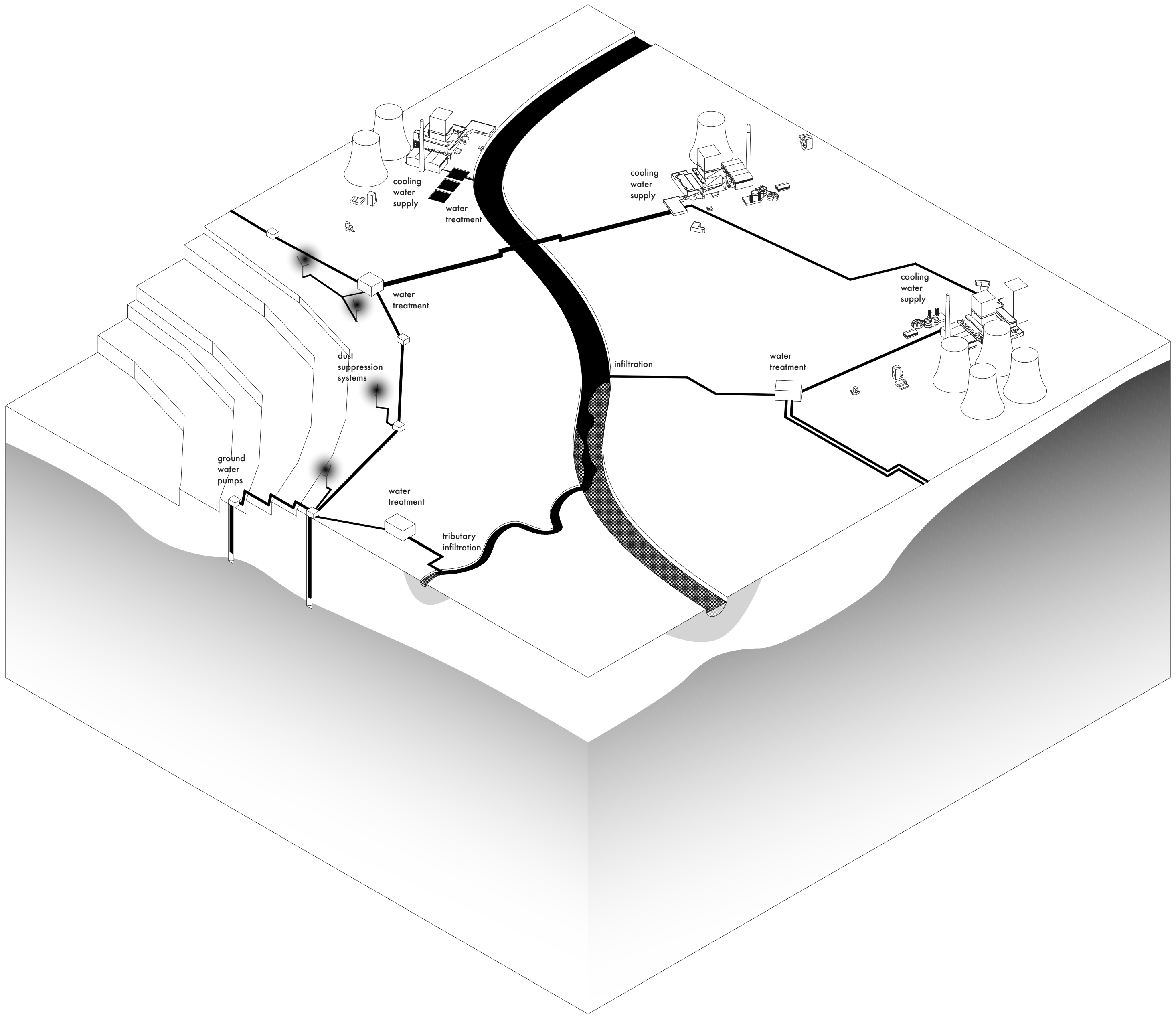


Fig. 20: The Entanglement of Water and Lignite Industry

Emerging from this historical reshaping of the river's behavior and terrain, we encounter the broader entanglement of industrial systems and environmental conditions. In the lignite mining landscapes of the Rhineland, the entanglement between industry and environment extends far beyond the visible machinery of extraction. It operates through systems of measurement, prediction, regulation, and response—interweaving technical infrastructures with ecological consequences. Industry has not simply occupied the landscape; it has reformatted it. This systemic entanglement is not limited to the control of water or the displacement of earth—it reaches into the underlying structure of how terrain is shaped, maintained, and imagined over time.

This entanglement is framed through two theoretical lenses. Timothy Morton's concept of the mesh offers a way to understand the interconnectedness of all things—living and non-living—through relationships that are non-linear, asymmetrical, and constantly shifting (Morton 2013). In the context of the post-mining landscape, the mesh becomes visible in the unexpected connections between groundwater resurgence, acidification, heavy metal mobility, and the slow unfolding of ecological response.

Water is not isolated within a hydraulic system; it is entangled with soils, infrastructures, policies, towns, and species.

Christophe Girot's definition of topology complements this view by focusing on the spatial expression of relationships in the landscape. For Girot, topology is not form, but condition—it is the mapping of presence, connection, and flow. Through this lens, the landscape becomes readable not as a static surface but as a field of interactions, shaped by deep time, human intervention, and material dynamics (Girot, 2013).

Together, Morton's mesh and Girot's topology form the theoretical foundation of this thesis. They allow for a reading of the Erft basin not as a bounded site, but as an evolving system—where water and matter, infrastructure and geology, memory and intervention co-produce space. Designing within this framework means participating in these interactions, acknowledging their depth and contingency, and working through them rather than against them.

The next section will focus on how water specifically acts as one of the central vectors through which these transformations occur—and how it might also become a medium for response.

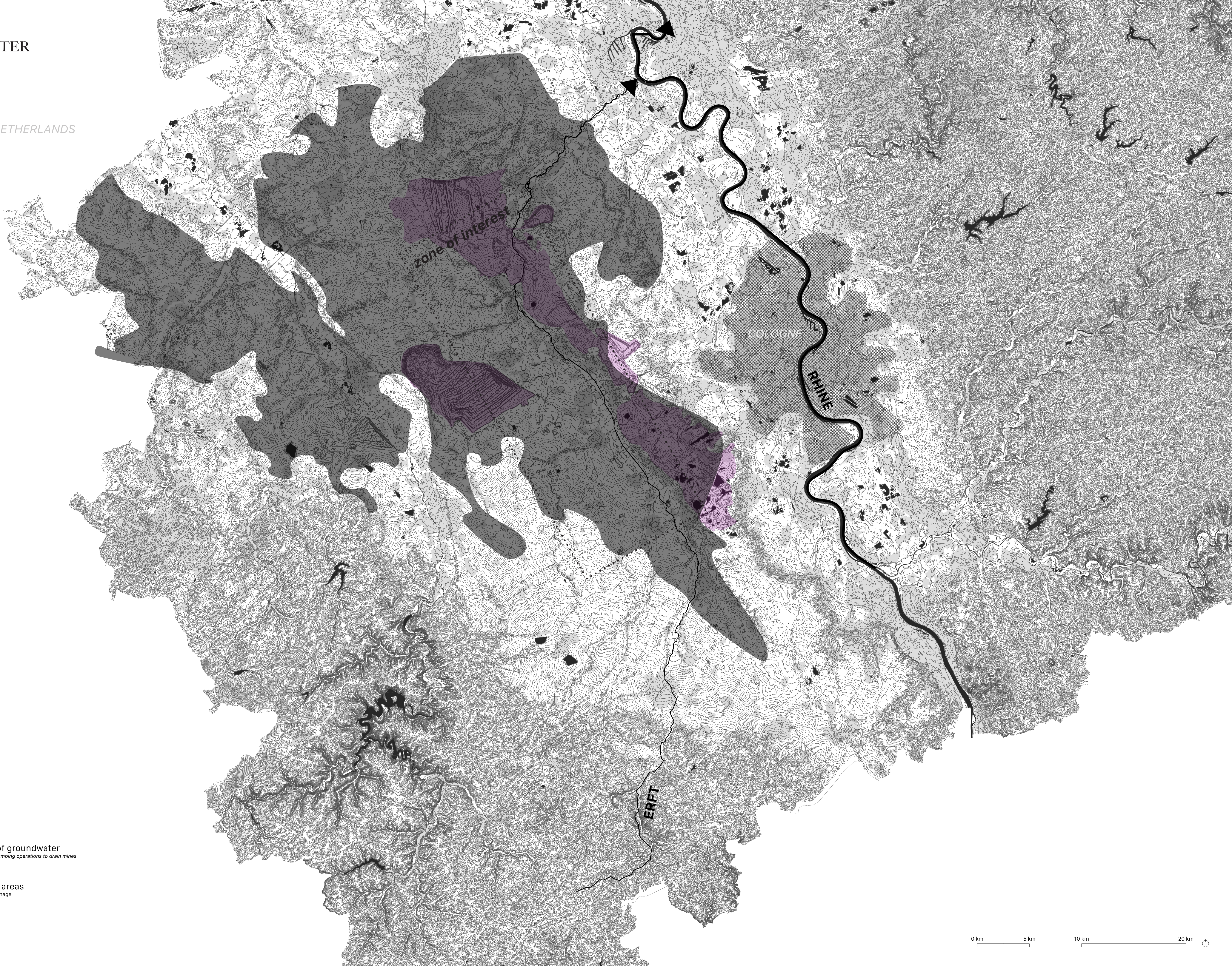
WATER

tracing contaminated flows

Fig. 21: Erft Infiltration

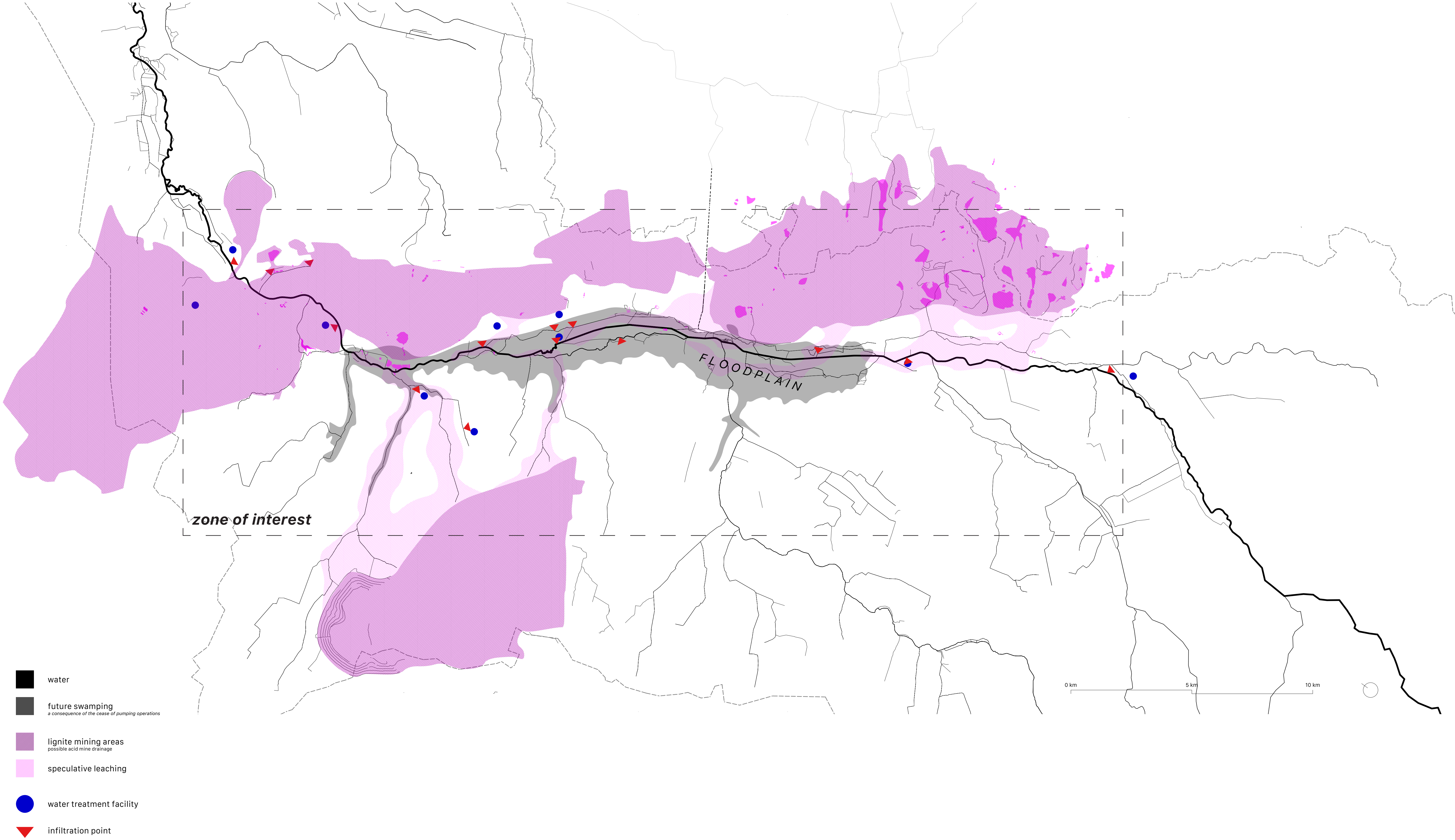
GROUNDWATER DRAINAGE

Fig. 22



BETWEEN TWO MINES
A RIVER

Fig. 23



WATER

Water, as both substance and system, becomes central in understanding the post-mining landscape. As lignite mining winds down across the Rhineland, groundwater pumping is gradually being reduced. This long-standing intervention—once necessary to keep open-pit mines from flooding—is beginning to reverse, allowing the water table to slowly rise. The reappearance of groundwater enables certain ecologies, such as wetlands, to re-establish themselves without the aid of artificial infiltration. The groundwater pumping, which previously helped regulate flood risks and suppress swamp formation across the basin, will gradually cease, allowing the return of these historically suppressed hydrological conditions. Yet, while this brings the promise of ecological regeneration, it also introduces new hydrological structures. The leftover mining pits will be flooded to create large artificial lakes—adding a further layer of complexity to the system, transforming not only the surface but also the way water moves, interacts, and is managed across the basin. Water is not only a carrier of life, but a medium of disturbance—a chemical memory of what has been altered.

Within the Erft river basin, this thesis identifies a hydrological territory shaped by drainage, extraction, destabilisation, disposal, and eventually, re-emergence.

The Erft basin traces a fluid and layered geography, where historical, geological, and hydrological processes converge and reverberate through the lignite mining region. It intersects the very center of extraction activities, linking forests, fields, wetlands, villages, infrastructure, and excavation sites. Throughout the past decades, it has been forced into new geometries through diversions, canalisation and weir systems, reinforcing a state of regulation. Originally a meandering river, the Erft has been increasingly redirected to serve industrial, agricultural, and flood-prevention purposes. Extensive canal networks and weirs not only control its flow but connect the river to the broader system of groundwater pumping and industrial water management. These infrastructures—designed to prevent flooding, enable extraction, and regulate flow—have become entangled with both ecological and technological processes, shaping what can be understood as a state of Neo Nature.

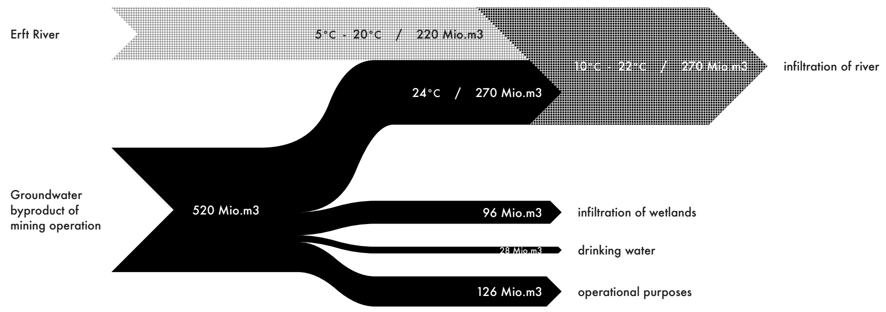


Fig. 24: Groundwater Infiltration into the Erft River

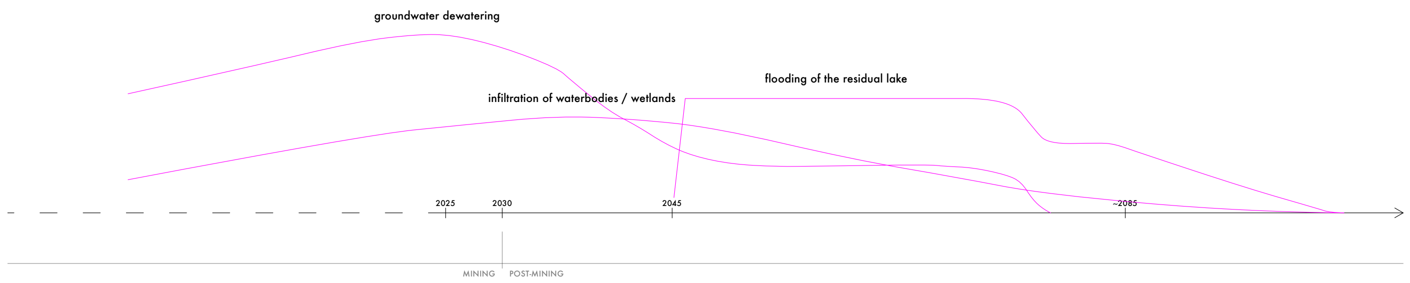
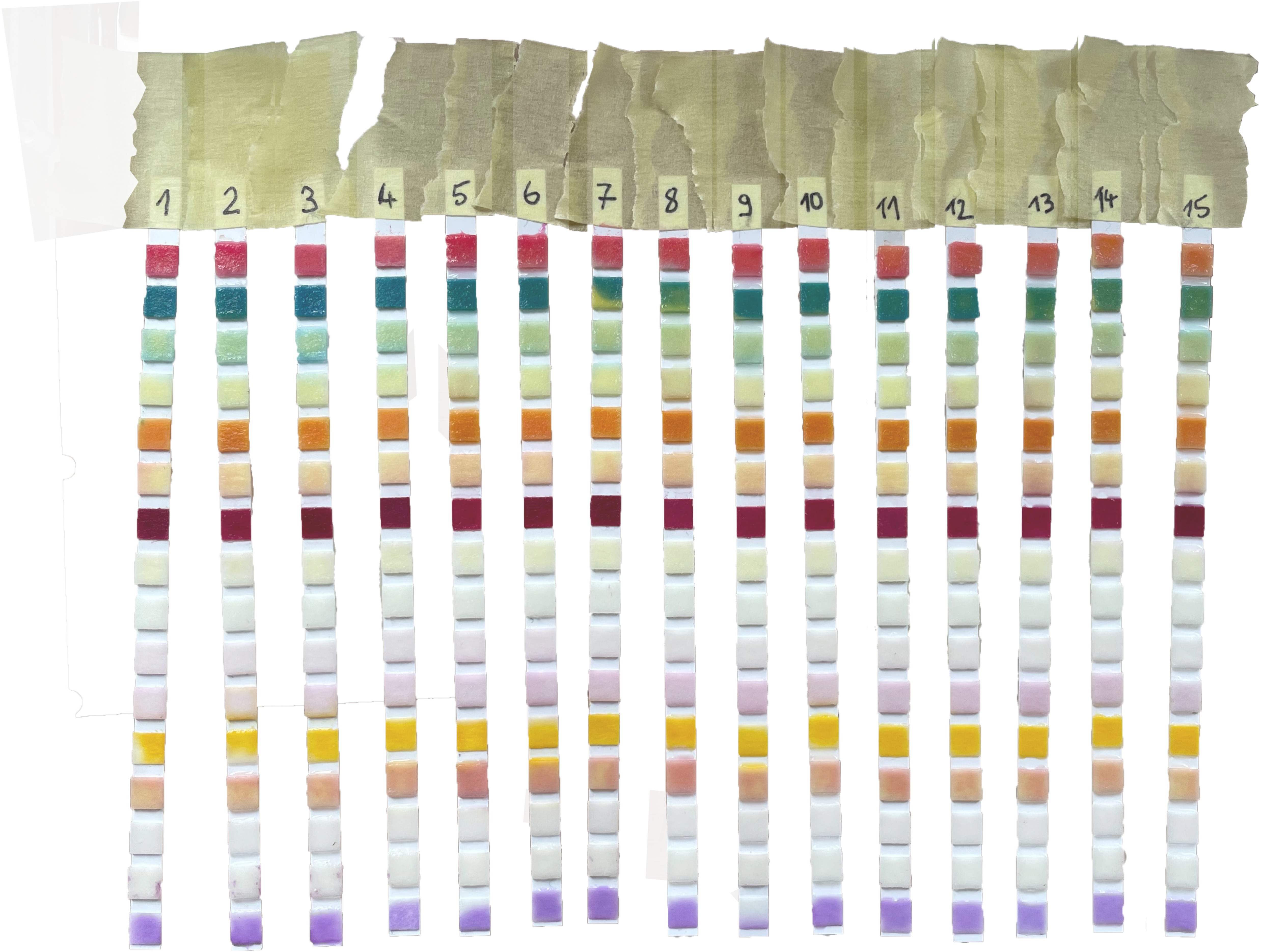


Fig. 25: Pumping and Infiltration, Past and Projections

WATER
INFRASTRUCTURES
Fig. 26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UNIFORM WATERS

The map displays water quality measurements taken at various points along the river, showing values that remain strikingly consistent. This uniformity is not the outcome of a stable ecosystem but the result of a tightly controlled hydrological regime—where water is extracted, treated, and re-infiltrated to maintain a managed condition. It reflects not ecological resilience but the enforcement of a specific environmental state, stabilizing the visible symptoms of degradation rather than addressing its systemic causes.

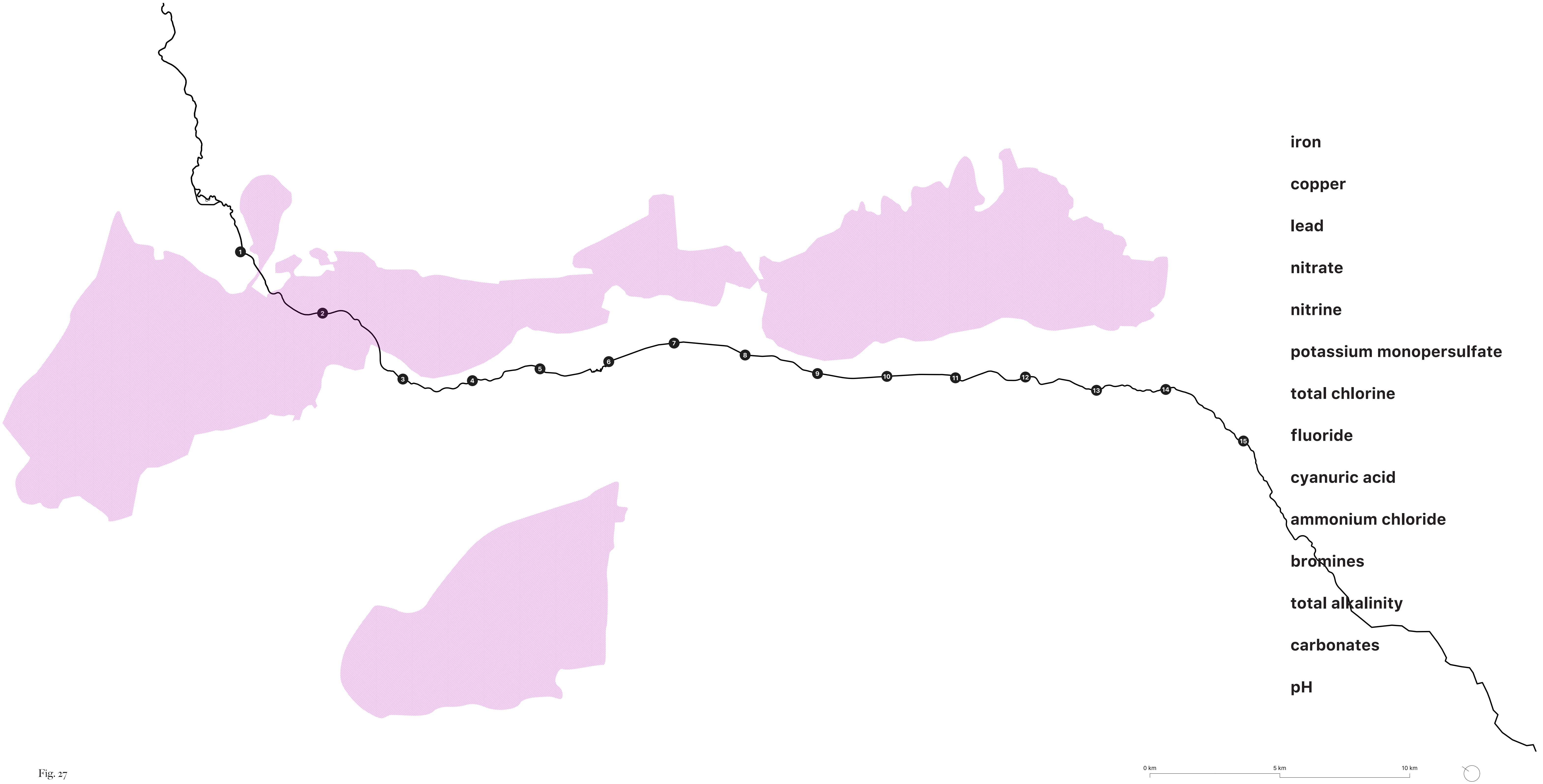


Fig. 27

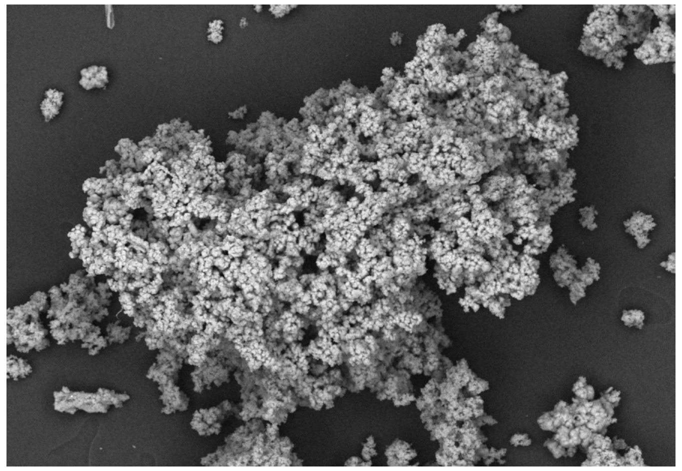


Fig. 28: Pyrite under the Microscope

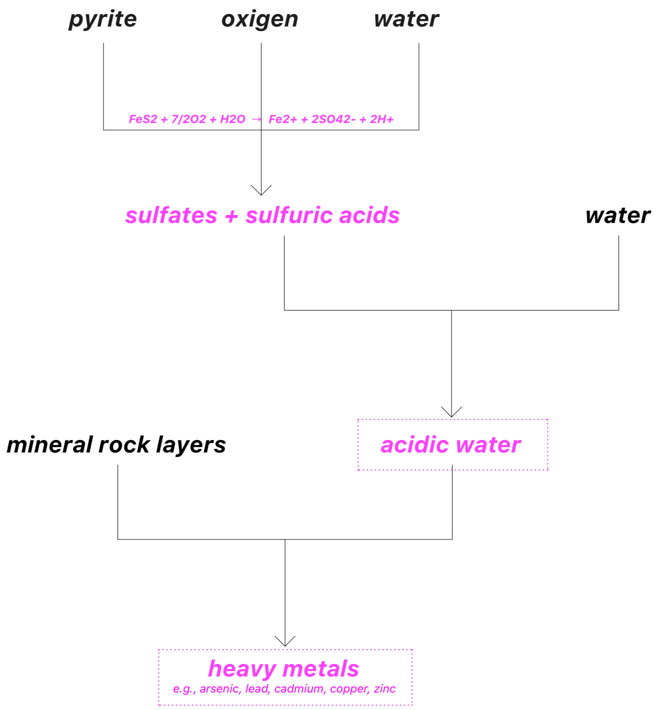


Fig. 29: Reactions and Consequences

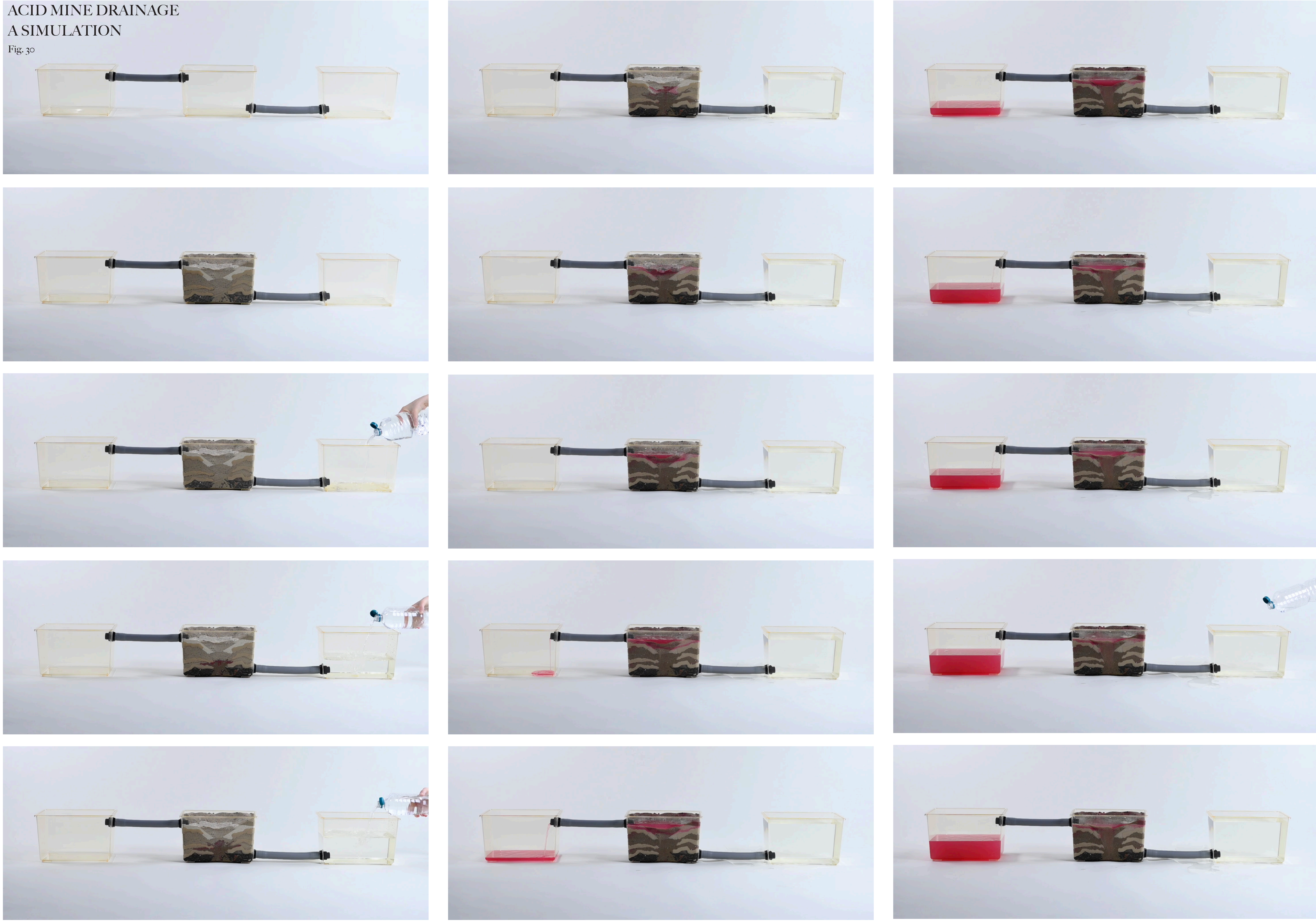
Open-pit lignite mining in the region necessitated one of the most extensive groundwater pumping systems in Europe. Over decades, massive amounts of water were removed from the subsoil to prevent the pits from flooding. This had cascading effects: the water table dropped, drying out wetlands and forest ecosystems; rivers and streams changed behavior; microclimates shifted. What was once an active hydrological regime became a managed and fragmented system of flows. But more than a disruption in volume or velocity, this intervention disturbed the very substrate of the region. Beneath the topsoil lies a sequence of geological strata—layers of sand, gravel, clay, lignite, and pyrite-bearing sediments—that functioned like a slow, filtering sponge. These were disrupted, displaced, and rearranged as part of the mining process.

What had been a stratified vertical logic—structured around geochemical balances and pressure thresholds—was rendered into a fragmented and incoherent mixture of materials.

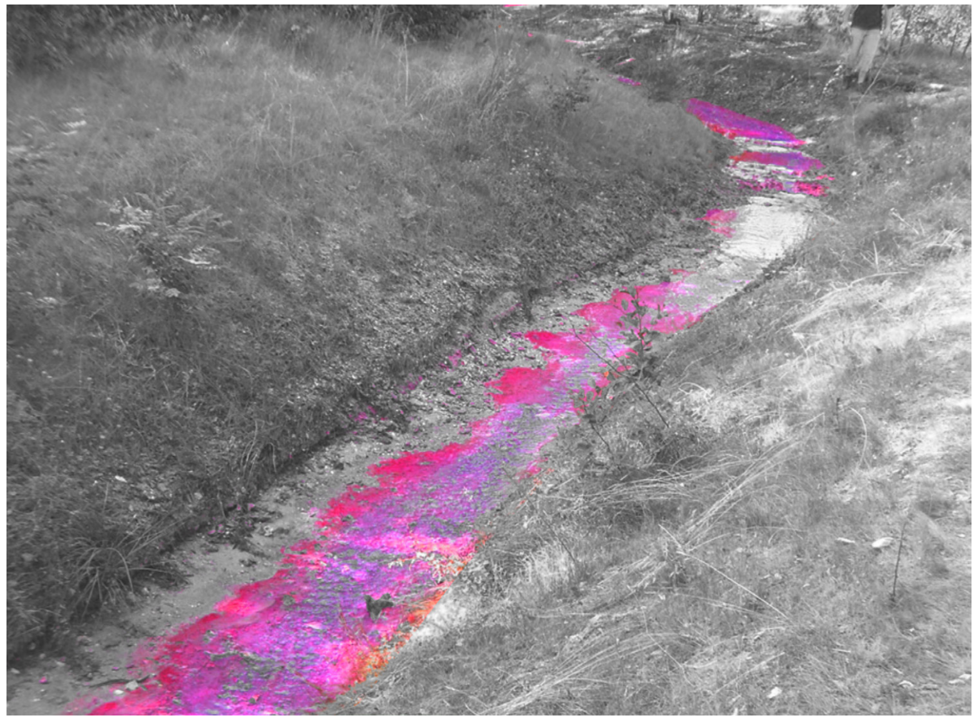
Crucially, this destruction of stratification enabled a dangerous chemical sequence. Pyrite (FeS_2), when buried and anaerobic, is relatively stable (see fig. X). But when brought into contact with oxygen—during excavation—and later with water—during groundwater resurgence—it undergoes a series of reactions that generate sulfuric acid. This acidification, in turn, dissolves heavy metals present in the sediment layers, creating a diffuse but persistent contamination.

Unlike oil spills or industrial leaks, this form of contamination is not a singular event. It is the consequence of an altered geological metabolism—a slow and distributed condition that unfolds over decades. The groundwater becomes acidic not all at once, but in gradients, in layers, and with cumulative effect. As the rising water interacts with these disrupted soils, it mobilizes metals like cadmium, zinc, and lead, transporting them laterally and vertically through the aquifer system.

Eventually, this altered water reaches the surface—through springs, wells, or direct seepage into the river system. The Erft and its tributaries become not only recipients but participants in this contamination. Their ecosystems shift subtly: algae blooms, microbial colonies, and invertebrate populations all respond to these chemical changes. What appears as a stable river is, in fact, undergoing slow metabolic transformation.



ACID MINE DRAINAGE
A SIMULATION
Fig. 30



„The region knew in the 1950s that the groundwater levels would drop significantly, and they consciously decided to settle the area, knowing the water would return one day.“

„RWE is a business, and their activities will gradually wind down, so ensuring ongoing accountability and financial provisions is crucial.“

„We are experts, but in detail, we‘re not immune to the occasional surprise when it comes to these systems.“

„The region will still face many challenges, possibly until the end of the century, some of which we can predict, but there will also be surprises.“

Stefan Simon, Erftverband – water management association, Groundwater Division

Fig. 31

CONTAMINATIONS

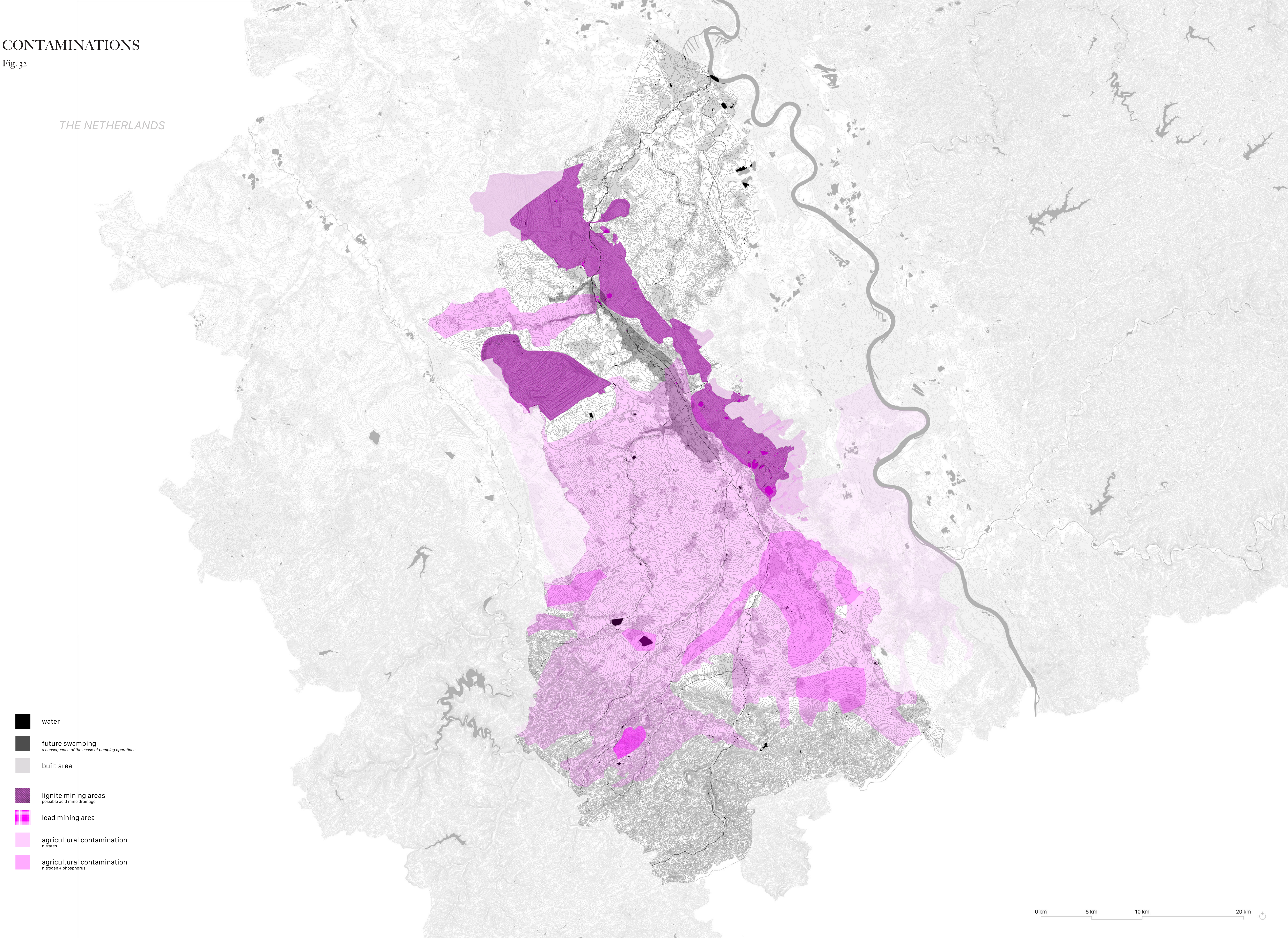


Fig. 32

This condition cannot be reversed by surface intervention alone. Planting vegetation or restoring riparian zones does little to halt the invisible chemical flows beneath. The problem is not located on the surface—it is geologic and hydrologic, nested in both depth and time. In this sense, the Erft basin becomes an transient landscape: it does not express a singular identity, but rather carries layers of inherited disturbance, active processes, and potential futures. It resists fixed categorization—it is neither natural nor industrial, neither healthy nor entirely toxic. It is becoming.

Recognizing this becoming demands new frameworks of engagement. Drawing from Latour's notion of the "Critical Zone"—the thin layer where life and geology interact—this thesis positions the Erft river not as a boundary between systems, but as a connector (Latour and Weibel 2020). A thread of possibility. Within this framework, water is no longer simply a substance. It is a medium of translation between surface and depth, past and future, ecology and infrastructure. To design within this system is to design with fluidity—not just as movement, but as transformatio
This perspective resonates with Lola Sheppard's framing of the epigenetic territory—where form, behavior, and structure are not fixed but shaped by interacting layers of ecological, geological, and technological systems (Sheppard, 2013). As Sheppard argues, architecture must abandon the closed logic of site-specificity and instead engage in the ongoing recalibration of dynamic, nested systems that stretch from the ground to the network.

Within the Erft basin, this recalibration must also reckon with the presence of inherited water infrastructure—canalised channels, flood protection systems, and weirs—that continue to regulate the river's flow. These systems, originally built to serve extraction and mitigate risk, now play a pivotal role in shaping the rhythms of both human and non-human life. By reprogramming these infrastructures—not through replacement, but through subtle adjustments in flow, delay, or permeability—there is potential to reorient the landscape's metabolic patterns. In this context, infrastructure becomes a mediator, not just of water, but of interaction and adaptation.

It is within this mesh of systems, constraints, and opportunities that the epigenetic territory reveals its potential—not as a fixed surface, but as a responsive field of transformation.

This means recognizing the mesh-like interconnectedness that Morton describes, in order to craft landscapes that are neither abandoned to contamination nor coerced into an idealized wilderness, but co-shaped in ways that accommodate both ecological processes and ongoing human needs. Far from an attempt to erase industrial legacies, this perspective invites deeper engagement with the long-term interactions among resources, technologies, and living organisms—embracing co-productive synergy as the most viable path forward.

Fig. 33: Weir Zieverich Mill

Fig. 34: Weir in Bedburg

Fig. 35: Weir in Bedburg

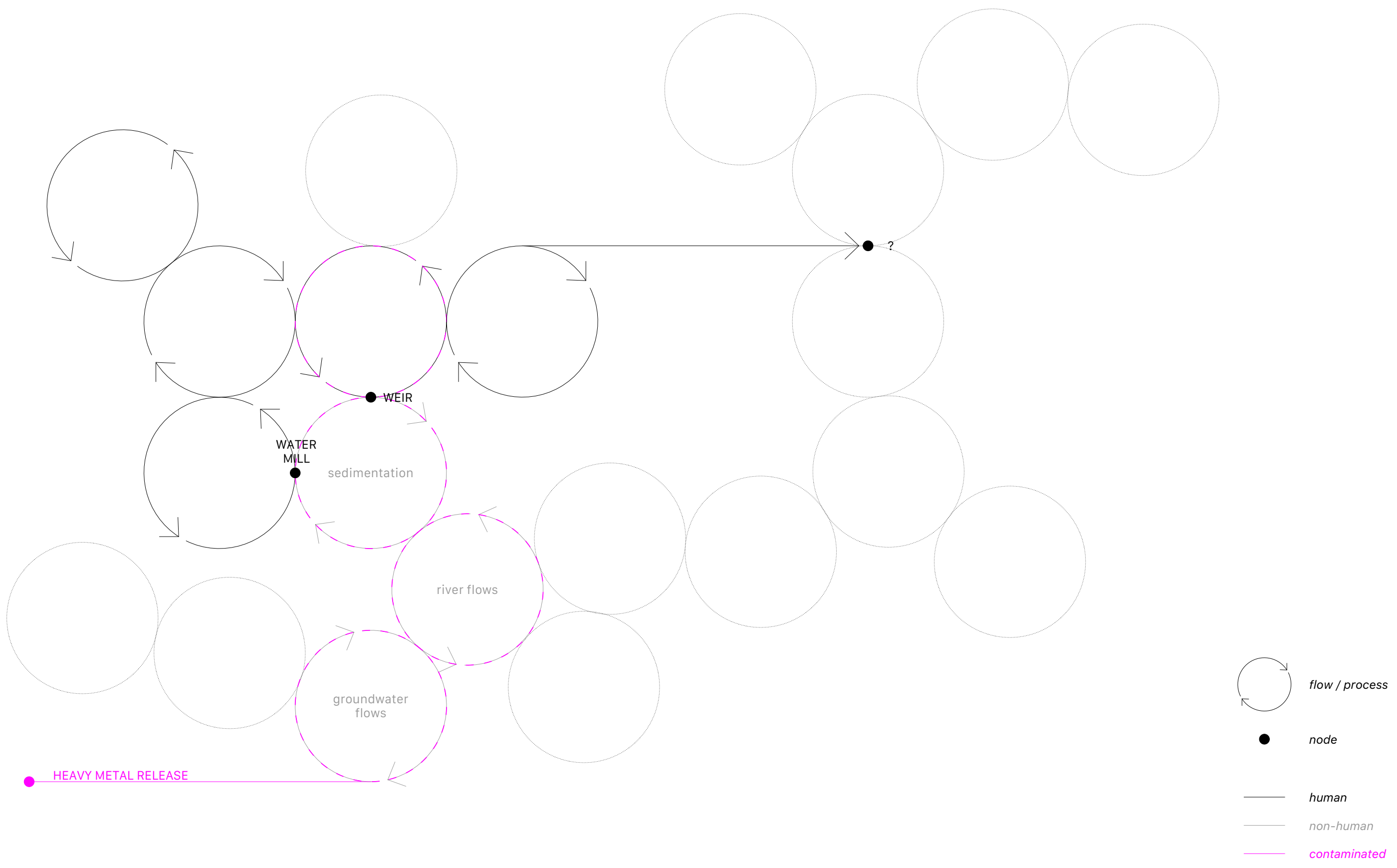


Fig. 36: Nodes and Flows

Smout Allen describe *Augmented Landscapes* as environments where natural processes and artificial systems are intertwined—spaces not of restoration or erasure, but of strategic enhancement (Smout and Allen 2017).

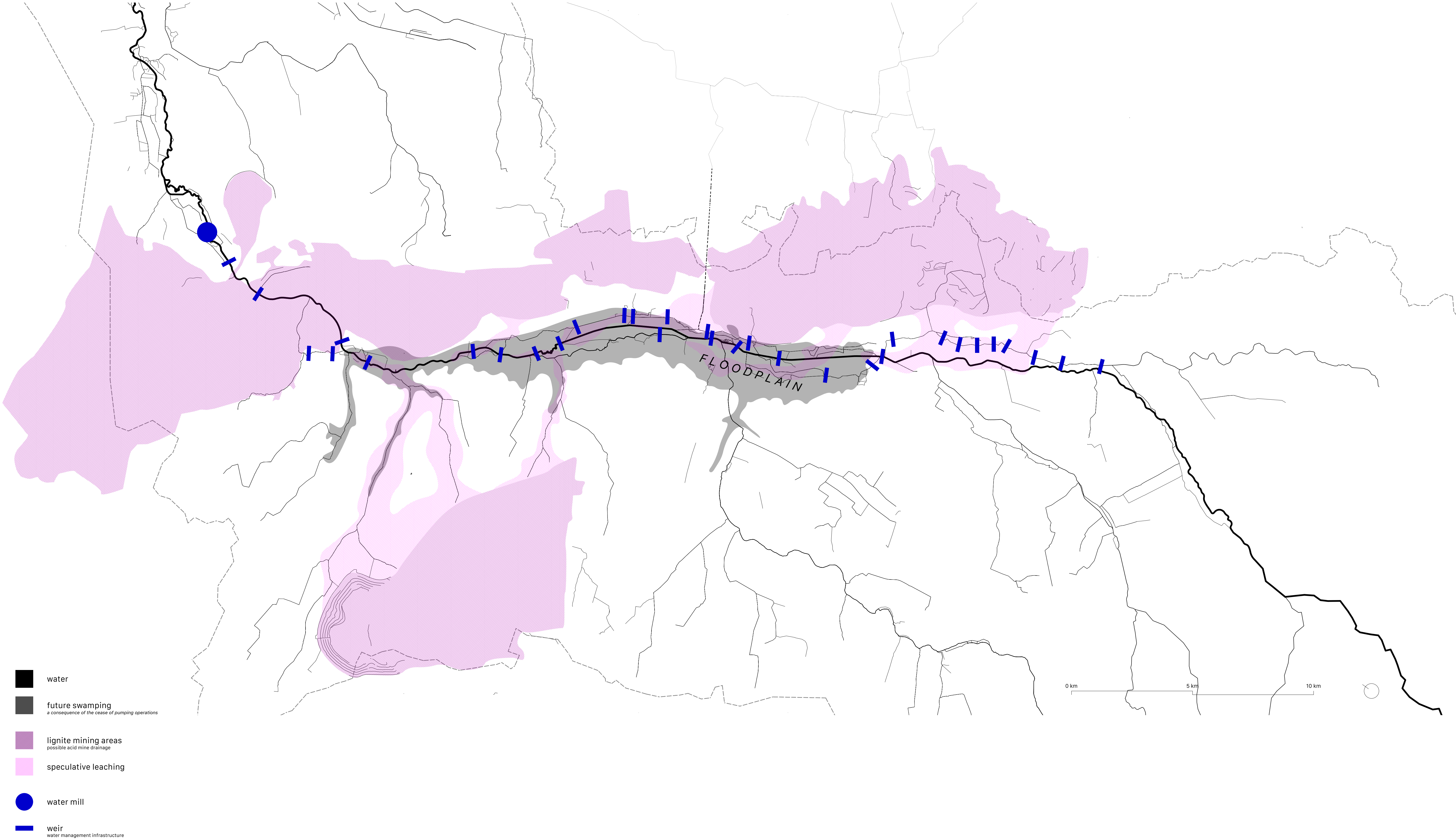
In these landscapes, design mediates between conflicting logics: ecological uncertainty, infrastructural rigidity, and atmospheric volatility.

Through calibrated interventions, the landscape becomes a responsive surface, continuously negotiating flows, pressures, and temporal shifts. These are sites where infrastructural and ecological systems are interwoven—landscapes in which design acts not through imposition, but through calibration and responsiveness to layered environmental conditions.

The research poses the following design questions: How can the evolving hydrological infrastructures of the contaminated landscape be reimagined as epigenetic territories—where water, contamination, and infrastructure co-adapt over time?
By reconsidering the role of abandoned power plants, water management systems, and historic mills as dynamic interfaces rather than fixed elements, this thesis explores new typologies of intervention that respond to shifting environmental conditions. By reprogramming elements of this existing water infrastructure—canals, weirs, retention systems—there is potential to reshape not only the flow of water but the spatial and temporal rhythms of human and non-human life that depend on it, creating an *Augmented Landscape*.

32 WEIRS AND A WATERMILL

Fig. 37



MATTER

altered states and material responses

Fig. 38: Matter

MATTER

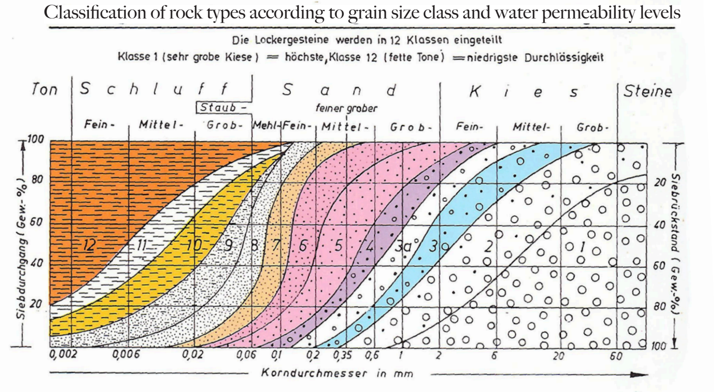
To operate within the dynamics of contamination requires moving beyond metaphors of purity, cleansing, or return. Instead, it demands an approach that engages directly with disrupted material flows and altered ecological metabolisms. In the case of the Rheinisches Braunkohlerevier, where water interacts with disturbed strata to produce acidification and mobilize heavy metals, the challenge is not to halt these processes, but to interact with them—to participate in their redirection, buffering, or gradual stabilization.

This research explores how site-specific materials and latent infrastructures might become agents in this interaction. It proposes distributed interventions that act as intermediaries between rising groundwater, disrupted geology, and surface ecosystems. These are not monumental projects but geological interfaces—insertions, compositions, and adjustments that mimic, absorb, delay, or transform the flows they encounter.

Water and matter interact constantly, not only as carriers and containers but as agents shaping each other over time.

Together, they create conditions—chemical, spatial, and temporal—that give form to landscapes. Their interaction defines processes like erosion and sedimentation, which in post-mining territories play an especially critical role. Sediment, in this context, acts not only as a geological layer but as a chemical reservoir. As acidic waters mobilize heavy metals, these are often absorbed or deposited into sediment layers, transforming riverbeds into *contamination sinks* that quietly archive the region's industrial history. Due to its important role within the contamination of the river, Sediment–as a material component of the river, with its agencies and reactions–became both the focus and the methodology of this research into how pollution unfolds and can be addressed within a fluid, ever-changing environment. Understanding this interplay is essential to designing with and within this contaminated system.

Classification of rock types according to grain size class and water permeability levels



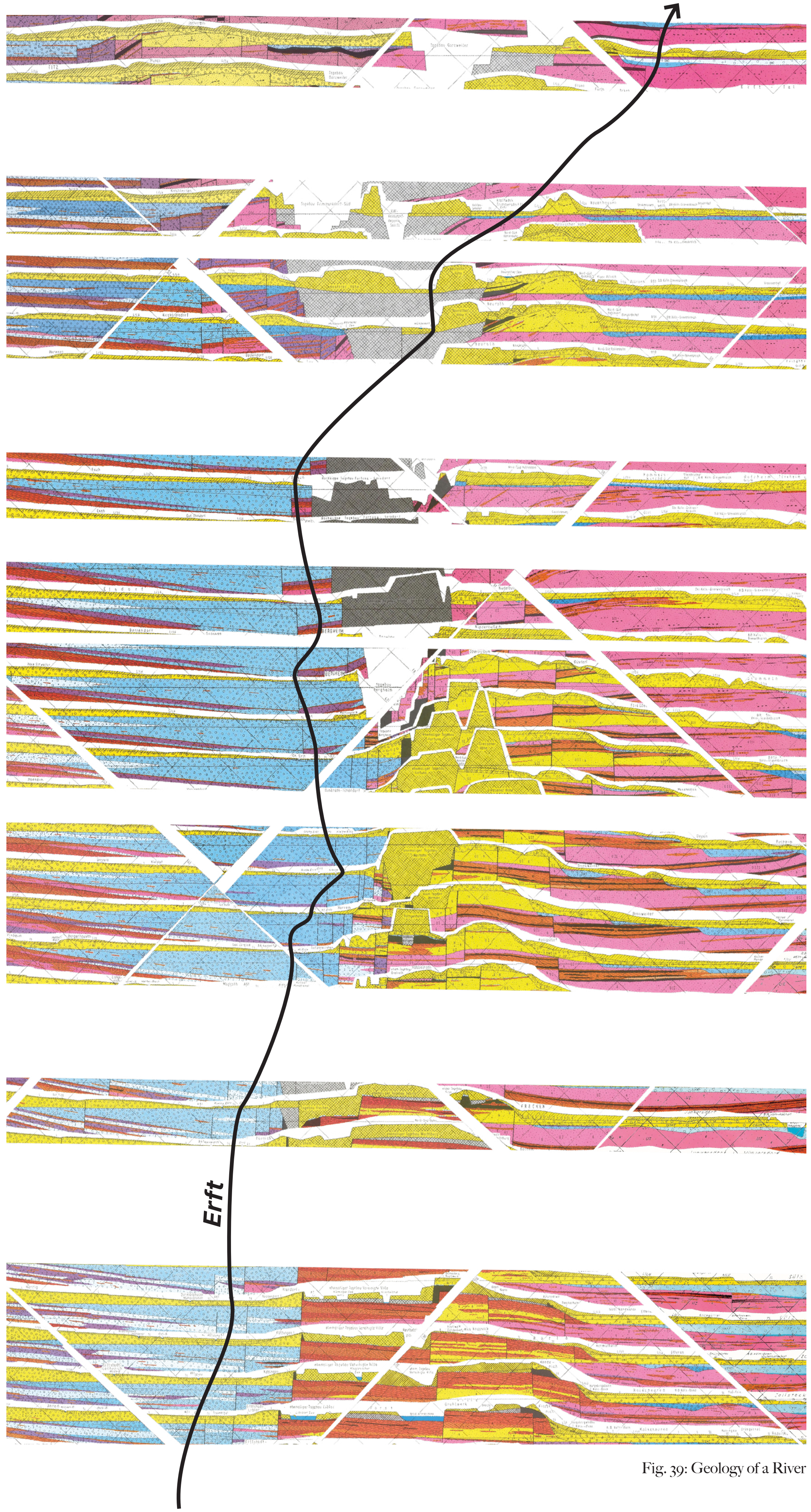


Fig. 39: Geology of a River

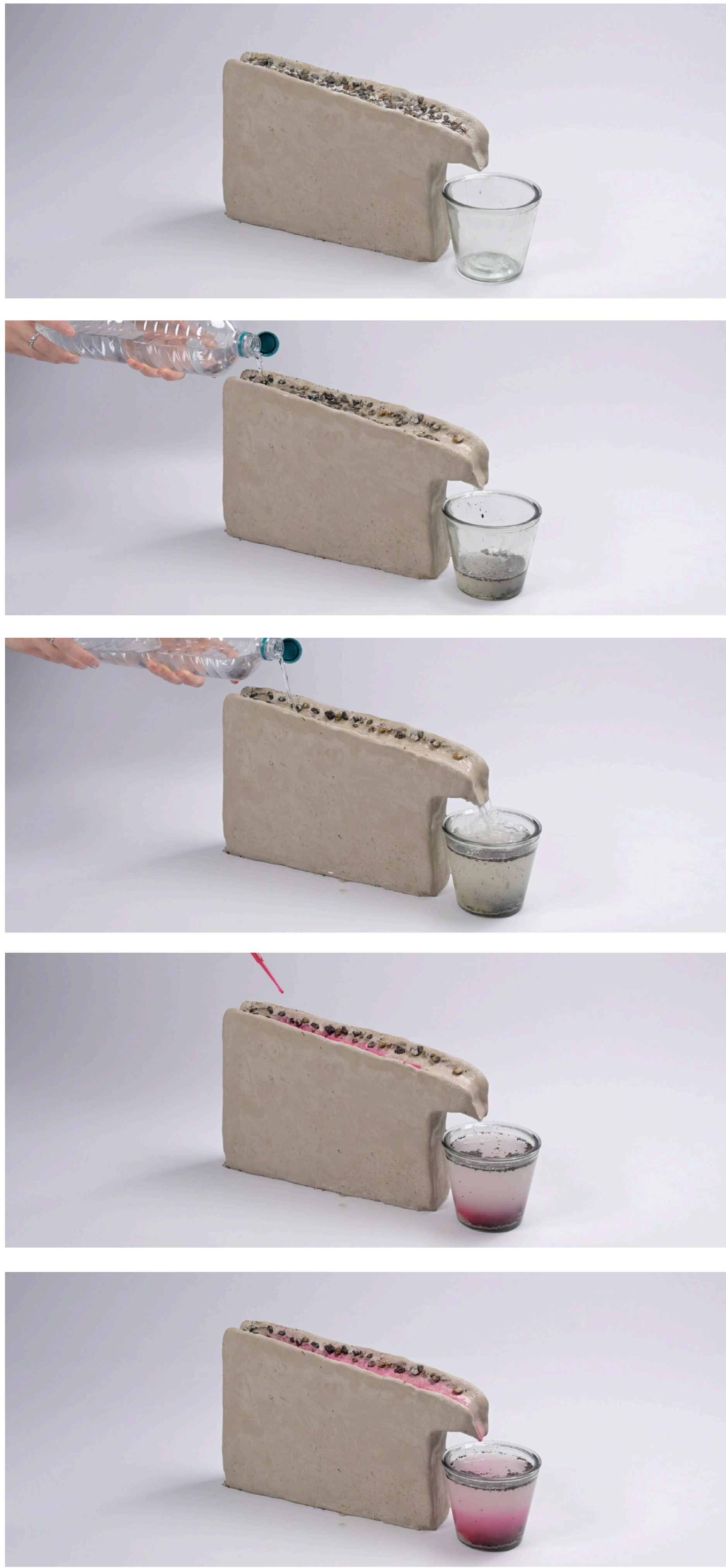


Fig. 40: The River as more than Water

Water dissolves, deposits, corrodes—it softens materials, binds them, or extracts their hidden chemistries. In turn, matter filters, absorbs, resists, and channels water's flow, creating new interfaces and transformations.

This dialogue between liquid and solid reshapes the environment from the microscopic to the territorial scale, producing shifting grounds, altered chemistries, and unpredictable ecological outcomes.

Understanding this interplay is essential to designing with and within this contaminated system.

Sedimentation follows a cycle of erosion, transport, and deposition that is directly shaped by the river's flow rate.

Fast-moving water erodes riverbanks and lifts sediment into suspension, transporting it downstream. As the flow slows—due to changes in river gradient, built structures like weirs, or seasonal discharge drops—the water loses energy and deposits heavier particles first, followed by finer ones (see fig. X). This creates layered sediment beds, which become long-term repositories for contaminants like heavy metals. However, these deposits are not inert. Seasonal fluctuations, such as increased rainfall or snowmelt, can sharply raise flow rates (see fig. X), disturbing these sediment layers. The result is a remobilization of trapped pollutants in sudden pulses—shock waves of contamination that move downstream, reacting chemically with new environments. These episodic releases tie the chemical history of the river not only to its past but to its ongoing hydrological rhythms.

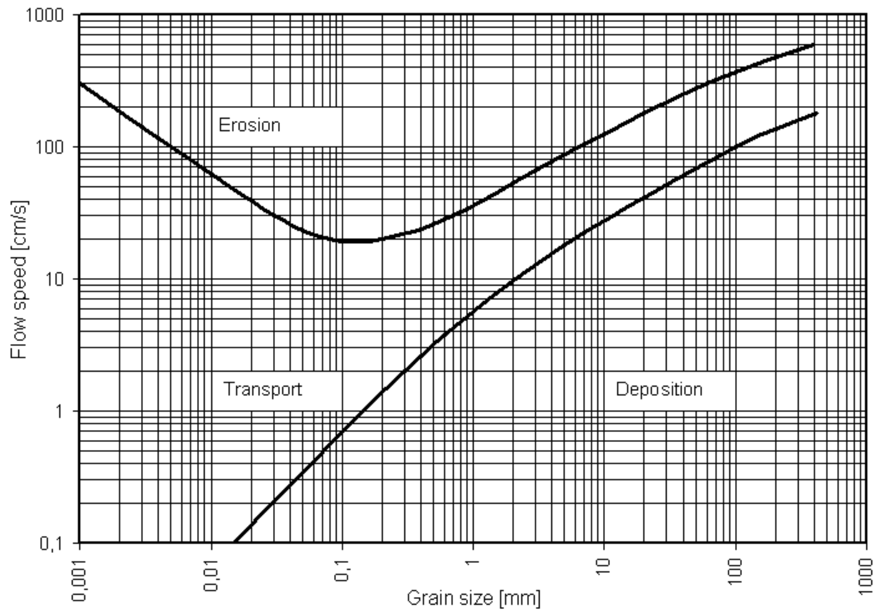


Fig. 41: Hjulström Curve on Correlation of Sediment Deposit to Flow Speed

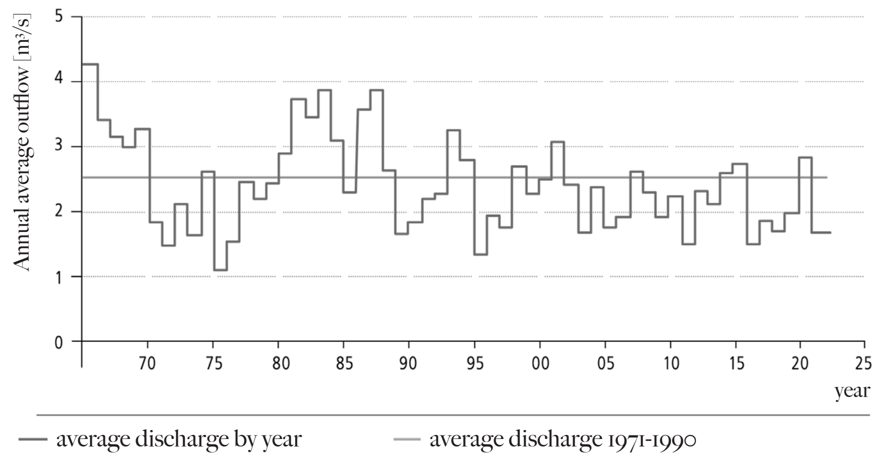


Fig. 42: Discharge Development at the Blicheim/Erft gauge

Central to this approach is the idea that matter itself is not passive but active and transitional. This resonates with Jane Bennett's notion of vibrant matter, in which she describes "a vitality intrinsic to materiality," and calls attention to the "capacity of things… to act as quasi agents or forces with trajectories, propensities, or tendencies of their own" (Bennett, 2010, p. viii). In this view, terrain is not a passive canvas to be shaped, but an assemblage of active matter—a field of dynamic substances and relations with the power to shape outcomes, respond to conditions, and exert influence beyond human intent. This emphasis on matter emerged from the need to continue and deepen the inquiry into water—not only as a carrier of contamination but as a transformative agent interacting with the ground. As the research followed water's vertical and horizontal movements through the disturbed geological strata, it became clear that these hydrological flows were inseparable from the materials they encountered, dissolved, or restructured. The focus thus shifted toward the material conditions that both influence and are shaped by water's chemical and physical behavior.

Matter became a way to engage the landscape not through abstraction, but through the very mechanisms of its transformation.

The ongoing chemical, geological, and hydrological processes triggered by lignite extraction revealed a terrain in flux—one that could not be addressed through form alone. Turning toward matter allowed the research to operate within this flux: to consider how materials behave, react, and evolve over time in direct relation to their environment. Material practices such as absorption, dissolution, binding, and erosion became not just chemical phenomena but spatial strategies—ways of designing with transformation rather than against it. In this context, matter becomes a collaborator in shaping conditions, and design becomes a process of adjusting and tuning, rather than asserting control.

Fig. 43: Erosion of Soil

MATERIAL ORIGINS

Fig. 44

The materials considered and researched in this thesis are not neutral—they are intimately tied to the territorial history and ongoing dynamics of the Rheinisches Braunkohlerevier. Among them, three locally sourced materials form the foundation of the proposed interventions: clay from Brüggen, fly ash from coal-burning byproduct landfills, and limestone from Wülfrath.

These materials—each shaped by industrial legacy—are reintroduced into the landscape with redirected purpose. Their manipulation—through excavation, relocation, compaction, and transformation—parallels, in form if not in intent, the very operations of extraction that once destabilized the region. Yet while mining fractured the substrate to extract energy, this approach uses the same logic in reverse: shifting materials to intervene in and reorient flows—not just of water and contamination, but of matter itself. By displacing and chemically altering local substances, the intervention introduces new gradients, absorptive layers, and reactive thresholds. These operations do not merely respond to existing conditions; they initiate new ones. In this sense, the act of material repositioning becomes an agent of transformation—mirroring the territorial impact of extraction while redirecting it toward stabilisation, buffering, and adaptive response.

In doing so, altered material states begin to reconfigure systemic flows—of water, energy, and contaminants—introducing new thresholds and delays that gradually reorient the conditions of the site.

The spatial repositioning and chemical activation of local matter becomes a strategic tool for redirecting ecological processes. Their transformation is not a departure from the site's history but a continuation of it, allowing interventions to grow from within the logics of the terrain. These materials' inherent and latent properties position them as mediators within a contaminated, yet still active, landscape. In doing so, the interventions intentionally mimic the very geological logics that were disrupted through mining—reintroducing stabilizing gradients, buffering capacities, and layers of transition.

The resulting forms can be understood as prosthetics to the landscape: not restorations, but functional augmentations that interface with ongoing processes rather than seeking to return to a prior state.

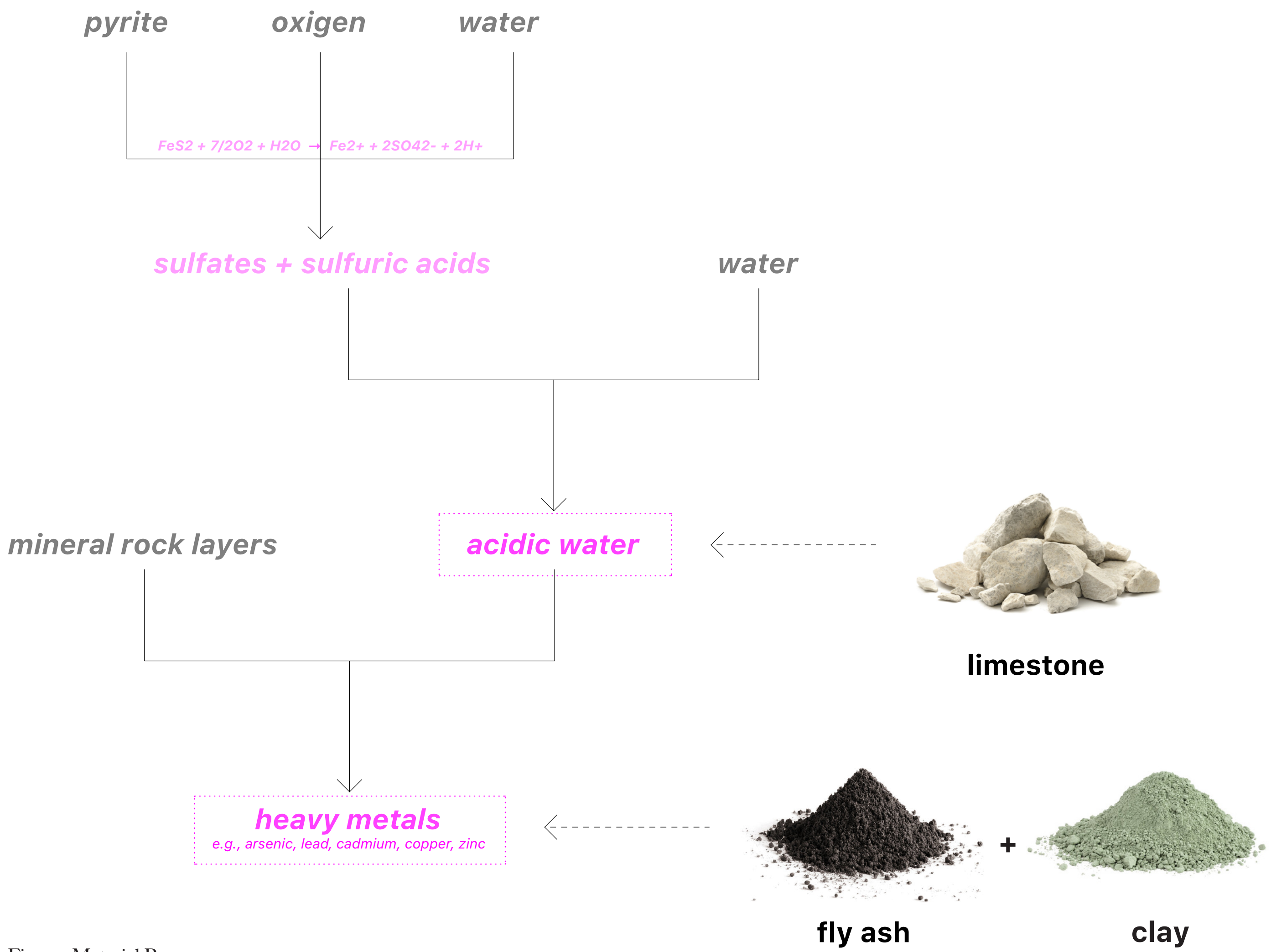


Fig. 45: Material Responses

Limestone contributes alkaline properties, allowing it to neutralize acidity and slowly dissolve into surrounding waters. This dissolution is not merely passive but reactive—it enables a form of self-regulation within acidic conditions, gradually buffering the environment and contributing to more favorable conditions for microbial and plant life.

Fly ash, a fine particulate residue of lignite combustion, is chemically reactive—capable of buffering acidic conditions and binding heavy metals through sorption and precipitation processes. Its porous structure and mineral composition allow it to trap contaminants, making it both a stabilizer and a filter in environments marked by chemical disturbance.

Clay gives shape to the fly ash. When fired, clay takes on ceramic properties that allow it to interact with its environment through absorption, retention, and gradual release. This responsiveness to environmental conditions—chemical, thermal, and hydrological—makes it an ideal vessel for facilitating exchanges across ecological and geological systems.

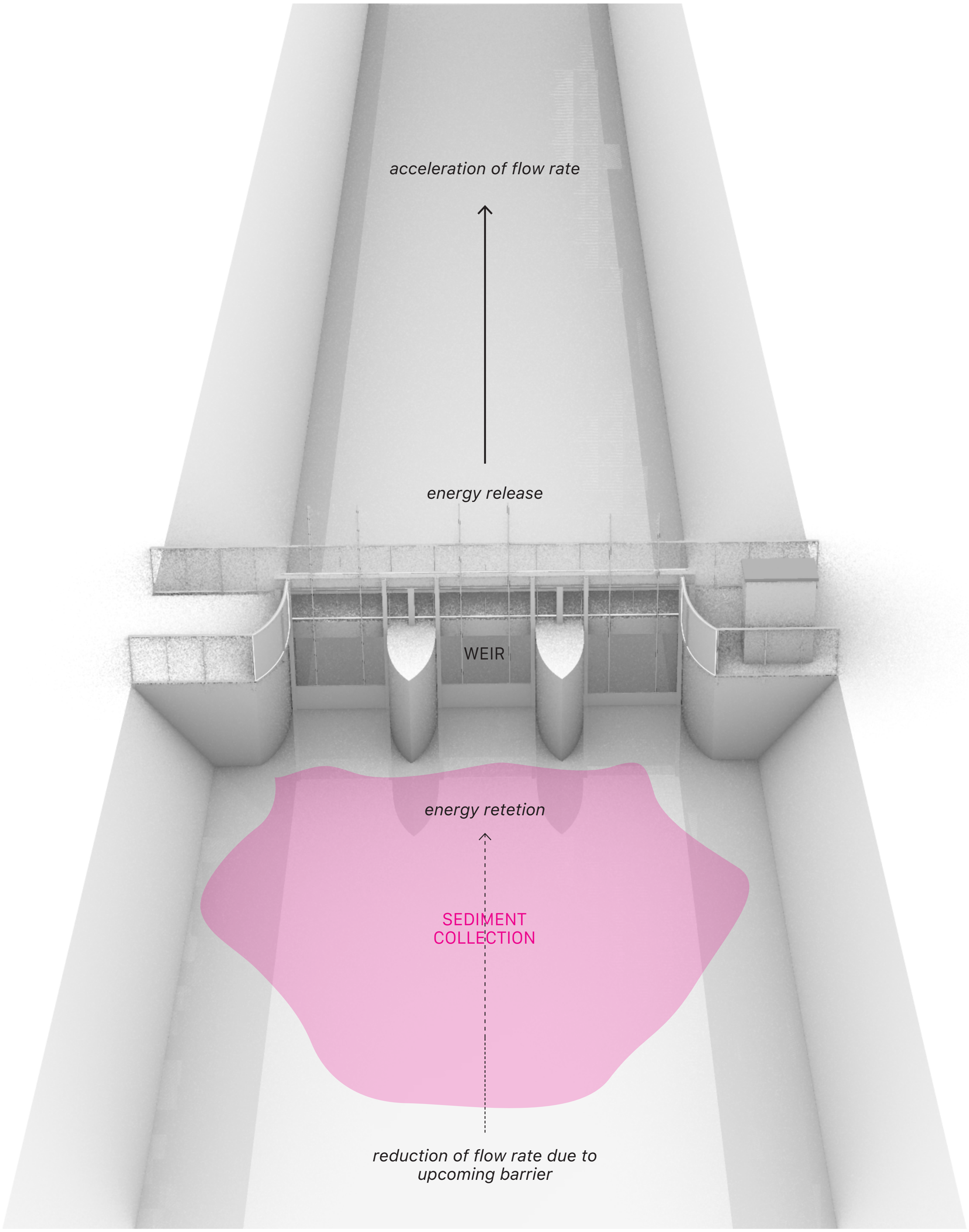


Fig. 46: Dynamics of Weir Systems

Rather than being organized around a singular architectural object, this thesis proposes a network of responsive components placed at key hydrological and geological interfaces. These components work within the logics of erosion, deposition, and seepage. Existing infrastructures—particularly canalised river sections and weir systems—play an instrumental role in this network.

Originally designed to manage water levels, regulate flow, and prevent flooding, these structures inadvertently create conditions that enhance sedimentation. By interrupting and slowing the flow rate, weirs cause suspended particles to settle, making them ideal collection points for contaminated sediments. As such, they become strategic interfaces for targeted intervention—locations where the interaction of water and matter is already concentrated, and where new layers of ecological function can be introduced with minimal disruption. These interventions are small-scale and partial, extensions of existing infrastructures. Their power lies in repetition, placement, and responsiveness rather than permanence.

The approach taken here draws inspiration from practices that engage with landscape as a dynamic register of energy, memory, and transformation. Smout Allen's hydrological Infrastructures, such as ‚Liquid Kingdom' and ‚Surface Tension', use speculative cartography and infrastructural insertions to both interpret and alter hydrological systems—suggesting ways of reading and writing landscape simultaneously (Smout and Allen 2018). Georges Descombes' work on the River Aire frames landscape as a negotiation between existing infrastructures and natural processes, allowing water to reintroduce sedimentation and ecological succession over time (Descombes 2013). Anuradha Mathur and Dilip da Cunha advocate for design strategies that work with water as a ubiquitous presence rather than a bounded object (Mathur and da Cunha 2009).

These practices share a commitment to engaging with the dynamic, processual nature of landscapes, using material and infrastructural interventions not to impose order, but to participate in ongoing environmental transformations.

This thesis argues for epigenetic design: an approach that understands spatial and material configurations as inheriting and expressing prior states, while remaining open to mutation and co-adaptation.

The goal is not to repair a landscape in the image of a prior ideal, but to construct infrastructures that can respond to the pressures of contamination, climatic variation, and ecological succession. *Matter* plays a pivotal role in this context—not simply as a resource or waste product, but as a medium through which contamination and adaptation are enacted. It is through the transformation, interaction, and reconfiguration of matter that these infrastructures gain meaning and effect. The project envisions these infrastructures as prototypical agents that might take different forms depending on context, available materials, and changing environmental needs.
Each intervention is a proposal—not a fixed solution, but a gesture toward coexistence within contaminated terrains. It embraces uncertainty and allows for degradation to become a process of spatial reconfiguration. Just as the landscape is not static, neither is the design. It is always in flux, always negotiating, always becoming.

The final section of the thesis will outline the design methodology that informs spatial strategies: a combination of spatial analysis, material testing, speculative prototyping, and systems thinking—structured to frame design as a process of continuous inquiry, attuned to the evolving conditions of the landscape.

GEOPROSTHETIC

projective frameworks

Fig. 47

Geo-: relating to the Earth or land.
Prosthetic: an artificial extension or device that replaces or enhances a missing or impaired part.

A Geoprosthetic refers to an artificial or designed intervention into the Earth or Landscape that acts as an extension, replacement, or augmentation of natural systems.

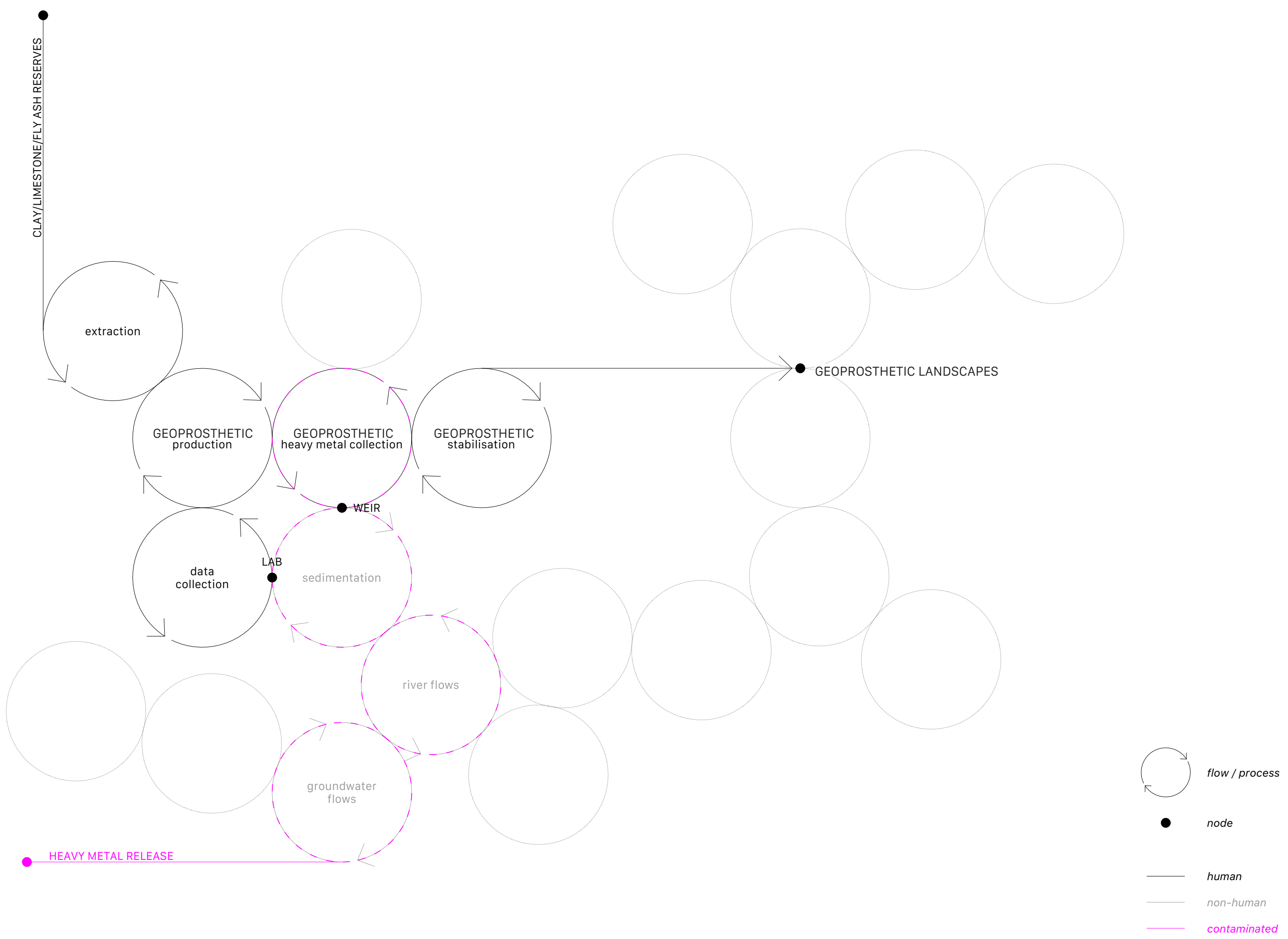


Fig. 48: Situating the Geoprosthetic in existing Flows

From Material Inquiry to Geoprosthetics

The research began with water—its role in mobilizing contamination, its routes through post-mining ground. Gradually, the lens widened to the materials it passed through. Sediments, residues, and layered earth revealed themselves not as backdrop but as agents—shaping conditions, redirecting flows, and accumulating change.

This shift reoriented the design approach. Rather than rely on fixed forms or mechanical systems, the project turned to matter—its behavior, its memory, its reactivity—as both medium and method. Out of this exploration, the geoprosthetic took form: a material device embedded in terrain, attuned to its slow shifts and capable of co-evolving with its instability.

The geoprosthetic is a speculative proposition grounded in material studies, drawing from research on adsorption, filtration, and sediment interaction. A detailed annotated bibliography of the studies informing this speculation can be found on page 99.

At the core of this thesis lies the concept of the geoprosthetic: a material interface designed to interact with the contaminated landscape through responsive, site-specific engagement. These are not monumental solutions but discreet, embedded interventions that extend the agency of matter and facilitate new relations between landscape, infrastructure, and ecological process.

A geoprosthetic is not an object of control—it is an instrument of negotiation. It emerges from the recognition that post-extraction terrains require more than remediation: they demand tools that operate within flux, rather than against it. The geoprosthetic is informed by geological processes—erosion, deposition, sedimentation, dissolution—and is situated where these processes converge with human-made systems. It does not seek to overwrite disturbance, but to metabolize it.

Three principles guide the implementation of the geoprosthetics:

Work with existing infrastructures:
Geoprosthetics are positioned at infrastructural nodes—such as weirs, culverts, and canal junctions—where hydrological flows are already concentrated, slowed, or diverted. These sites offer the spatial and mechanical conditions necessary for sedimentation and chemical buffering. They are not blank sites, but latent interfaces where matter and water already accumulate.

Respond to flows, not forms:
Rather than imposing fixed designs, each geoprosthetic is shaped by and responsive to the specific flows—of water, contaminants, thermal variation, and biotic interaction—present at its site. It reads and reacts, absorbs and releases, delays and redirects. By repositioning and reactivating materials within these flows, the geoprosthetic enables a redirection of energy and substances through the landscape. This is not about halting change, but guiding it—constructing new gradients, filters, and porous edges that modulate rather than block.

Build from within the terrain:
The geoprosthetics, composed of site-bound substances like clay, fly ash, and limestone, intervene not through abstraction but through situated responsiveness. They engage in local transformations—absorbing, neutralizing, binding—and in doing so, alter the conditions around them. Their placement repositions material flows, redirects energies, and initiates feedback loops that exceed the object itself. This is not an isolated act of repair, but an insertion into an evolving terrain.

Through these principles, the geoprosthetic becomes both method and medium: a conceptual and material tool for inhabiting contaminated landscapes with observation, experimentation, and responsiveness.

REFLECTION

1. What is the relation between your graduation project topic, your master track, and your master programme?
This work intersects the realms of ecology, infrastructure, and territory—addressed through a cross-disciplinary studio within the Architecture track. It contributes to the MSc AUBS by offering a design approach grounded in systems thinking, material engagement, and adaptive responses to contamination. Through the lens of post-lignite landscapes, the project integrates spatial design with theoretical and material inquiry, making visible the potential of a terrain often highly controlled and rigid.

2. How did your research influence your design, and how did the design influence your research?
The design grew directly from research, and vice versa. The developed martial practice is not a design afterthought but a conceptual outcome of tracing material behavior and environmental feedback. Initial explorations focused on hydrology, but gradually evolved toward the agency of matter. This led to an embedded design approach that operates through placement, responsiveness, and interaction with existing systems. The act of designing speculative prototypes fed back into the research, helping define the nature and limits of material reactivity, infrastructural capacity, and site-specific response.

3. How do you assess the value of your way of working (your approach, methods, and methodology)?
The project values slowness, iteration, and embeddedness. The tools—mapping, theorization, testing—allowed for an evolving rather than predetermined process. Due to the complex and interdisciplinary nature of the subject—intersecting geology, hydrology, environmental engineering and design—it became necessary to shift toward informed speculation. Relying solely on empirical certainty proved limiting; instead, studies, models, and analogs grounded speculative interventions and allowed for continued progress without oversimplifying the issue.

4. How do you assess the academic and societal value, scope, and implication of your graduation project, including ethical aspects?
This project positions contamination as a terrain for engagement, not restoration. Academically, it contributes to discourse on post-extraction terrains as active and unfinished systems, on infrastructural reactivation beyond technical optimization, and on material agency as a design driver in unstable environmental conditions. Societally, it opens up future imaginaries for neglected sites while refusing aestheticized or reductive notions of repair. Ethically, it frames intervention not as mastery but as cohabitation—allowing unstable systems to adapt without prescribing fixed futures.

5. How do you assess the transferability of your project results?
While grounded in the Erft basin, the logic of geoprosthetic thinking is transferable to other territories where contamination, infrastructure, and ecological flows intersect. It does not rely on universal forms, but on situated practices that respond to locally available materials, infrastructures and environmental conditions. It encourages a systemic reading of the terrain, where resilience emerges not from rigidity, but from strategic interrelations and latent capacities. In this framework, design becomes a way of revealing and working with these interdependencies. The emphasis shifts toward mapping how components connect, support, or stress one another over time. By focusing on these interactions, the project highlights how the activation of latent relations—rather than the addition of new infrastructures, materials or boundaries—can enable environmental and infrastructural self-adjustment. This allows the design to remain grounded and materially situated. Its strength lies in its openness, feedback loops and adaptability.

6. How can architecture remain responsive in evolving landscapes shaped by disturbance and uncertainty?
The thesis proposes that architecture can act as a tool for modulation and participation rather than resolution. Through the geoprosthetic, the project demonstrates how design can respond to instability—absorbing, buffering, and interacting with it—without seeking finality or closure. Rather than framing outcomes as complete, the design embeds itself within ongoing processes, evolving alongside shifting systems and conditions. Landscape and design continuously shape one another through feedback loops, each adjusting to the other over time. The design itself is not predefined or static; it remains open-ended and never fully finished. Its strength lies in its ability to remain responsive—adapting as the landscape transforms, and in turn, subtly influencing those transformations.

7. How does this project challenge conventional distinctions between nature and infrastructure?
This project begins from the premise that the binary between nature and human intervention—often reinforced through restoration or preservation practices—no longer holds in the post-extraction landscapes of the Rhineland. Here, nature is not pristine; it is entangled with pipes, ash, drainage basins, and engineered rivers. The design does not attempt to separate or idealize these conditions but works within their mutual dependencies. By placing responsive, material-based interventions within infrastructural nodes, the project reframes nature as an evolving, co-produced system. Rather than assigning roles—natural vs. artificial—it reveals how landscape and infrastructure co-shape each other through time, feedback, and transformation.

Annotated Bibliography

This annotated bibliography compiles key studies that inform the material and functional logic of the geoprosthetics designed for water remediation in post-mining landscapes. The selected literature provides a scientific foundation for the speculative use of fly ash, clay-fly ash composites, and limestone as active agents in decentralized, landscape-integrated filtration systems.

Studies on Fly Ash Properties for Heavy Metal Binding

1. Adsorption Performance of Modified Fly Ash for Copper Ion Removal from Aqueous Solution. Water, 13(2), 207.

This study supports the concept of fly ash blocks as active heavy metal absorbers by demonstrating how chemical modification improves binding capacity.

2. Copper and Cadmium Adsorption on Pellets Made from Fired Coal Fly Ash. Journal of Hazardous Materials, 148(3), 538–545.

Illustrates the potential of solidified forms of waste-derived materials (like pellets or blocks) for metal capture, validating the pelletization strategy.

3. Phosphorus Retention by Fly Ash Amended Filter Media in Aged Bioretention Cells. Water, 9(10), 746.

Shows the multifunctionality of fly ash in water treatment beyond heavy metals, supporting its inclusion in multi-functional filtering geoprosthetics.

4. Municipal Solid Waste Fly Ash-Derived Zeolites as Adsorbents for the Recovery of Nutrients and Heavy Metals—A Review. Water, 15(21), 3817.

Explores the transformation of fly ash into zeolites, underlining the potential for value-added processing of waste materials into advanced filters.

Studies on Clay/Fly Ash Composite as Filter Medium

1. Ceramic Membrane-Based on Fly Ash-Clay For River Water Treatment. Biointerface Research in Applied Chemistry, 13(5), 430.

Demonstrates the synergy between clay and fly ash in forming ceramic membranes for water purification, directly supporting the project's block material formulation.

2. Utilization of Constructed Wetland for the Removal of Heavy Metal Through Fly Ash Bricks Manufactured Using Harvested Plant Biomass. Ecohydrology, 15(4), e2424.

Extends the application of clay-fly ash materials into the domain of phytoremediation, reinforcing the concept of hybrid remediation systems combining material and plant-based strategies.

3. Application of Coal Fly Ash Based Ceramic Membranes in Wastewater Treatment: A Sustainable Alternative to Commercial Materials. Heliyon, 10(2), e24344.

Supports the safety and effectiveness of using clay-fly ash mixtures for water filtration, validating the environmental viability of the proposed block system.

Studies on Limestone as pH Regulator

1. THE EFFICIENCY OF LIMESTONE IN NEUTRALIZING ACID MINE DRAINAGE — A LABORATORY STUDY. Carpathian Journal of Earth and Environmental Sciences, 12(2), 347–356.

Provides data on limestone's performance in neutralizing acid mine drainage, backing its role as a slow-eroding pH buffer in contaminated waters.

2. A Spatial Analysis of Lime Resources and Their Potential for Improving Soil Magnesium Concentrations and pH in Grassland Areas of England and Wales. Scientific Reports, 11, 20420.

Confirms the buffering capabilities of limestone in a controlled environment, further supporting its role in pH regulation for contaminated mining landscapes.

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