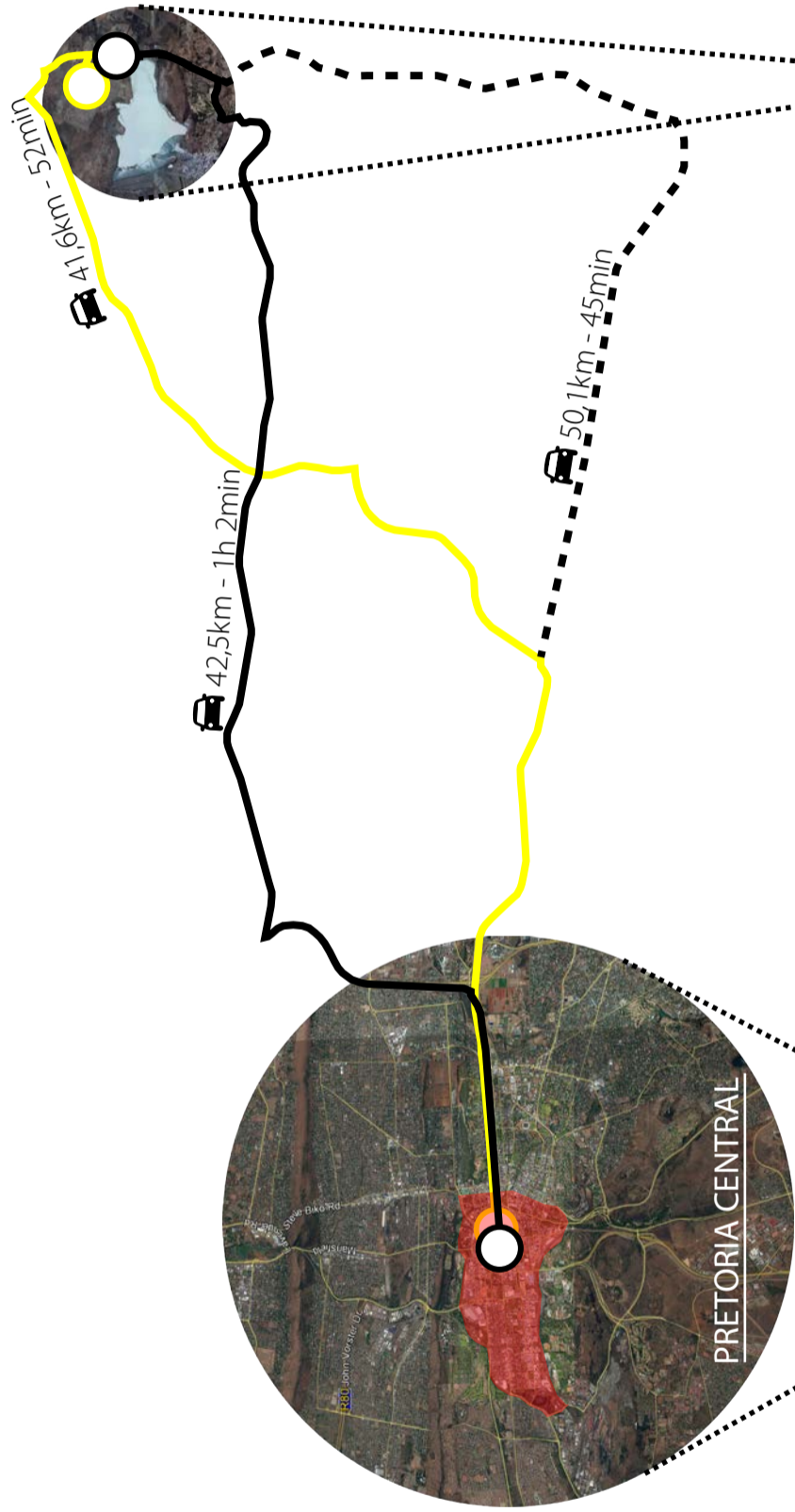


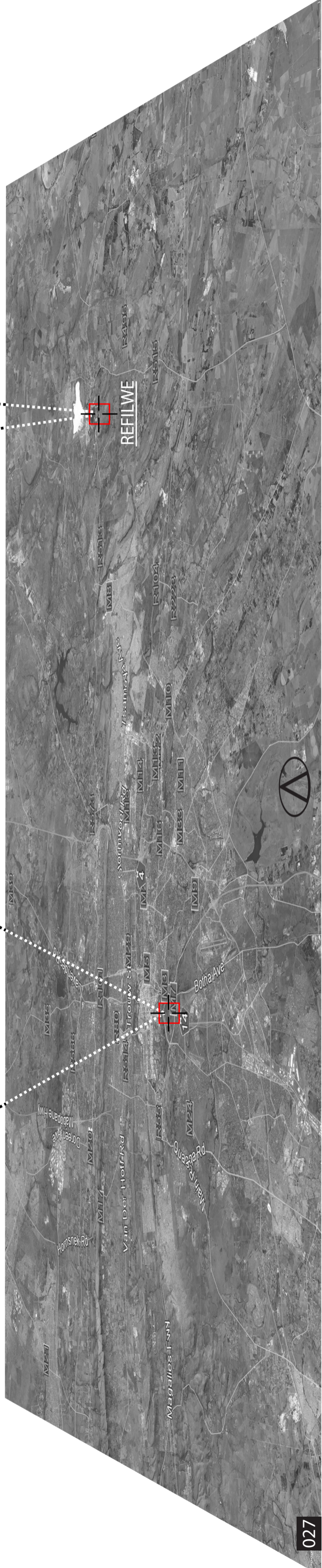


CHAPTER 02  
CONTEXT

- ROUTE OPTION 1
- ROUTE OPTION 2
- ROUTE OPTION 3



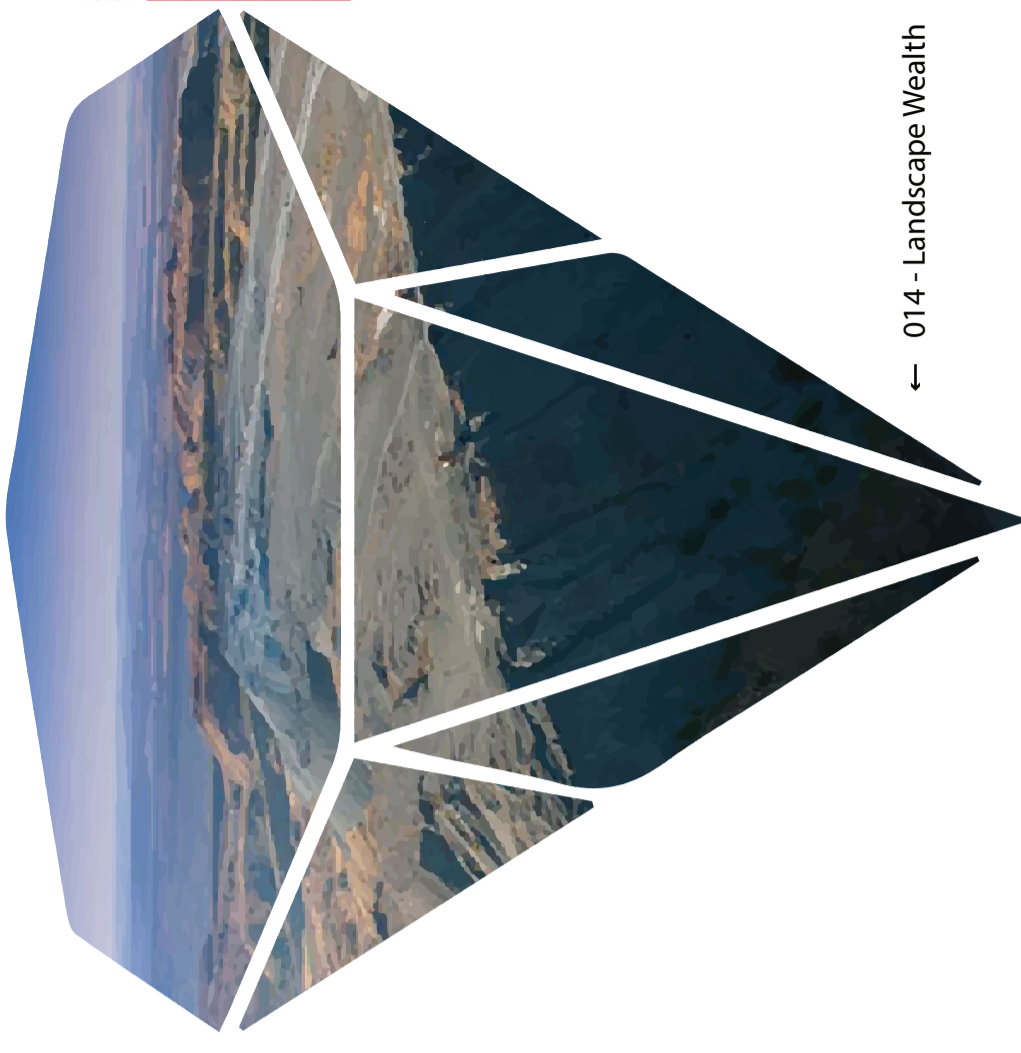
← 013 - Locate - Macro

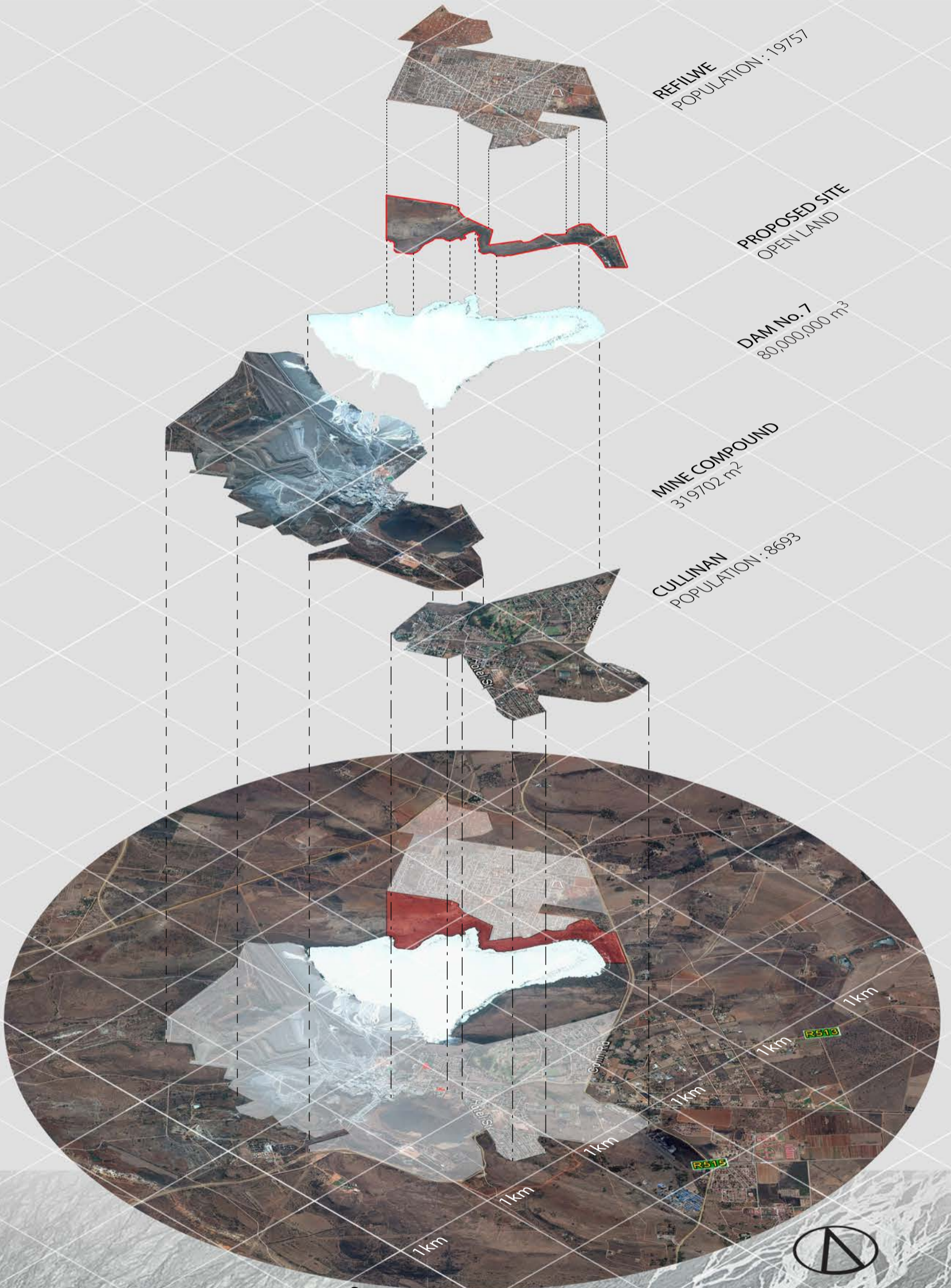


## 2.1// THE HISTORY OF CULLINAN

Cullinan is a small mining town east of Pretoria city (as previously mentioned in Chapter 1 of this dissertation). Cullinan is unbeknownst to most people internationally, even locally, yet the mine has had an international impact. In 1905 Mr. Frederick Wells discovered the diamond known today as the Star of Africa. The diamond was sold to the historical Transvaal government the same year as its discovery, to ensure the financial stability of the mine. In 1907 the Star of Africa was given to King Edward VII, for his 66th birthday. Today it can be found on display in the Tower of London, as part of the Crown Jewels collection. The Star of Africa is set into the Imperial State Crown of Great Britain (Famousdiamonds.tripod.com, 2017). The Star of Africa is only one of a great number of diamonds, that hold international acclaim, discovered at the Cullinan mine.

Cullinan mine utilizes a mining method known as mechanized panel retreat block caving. This process requires the development of an open drilling level, where the ore body is then undercut by drilling and blasting (Bester, 2005). This method has resulted in a large open incision in the landscape better known as the “The Cullinan Big Hole”. The Cullinan Mining Hole is currently estimated to be 1000m in length, 400m in breadth and 500m deep (Mining Technology, 2017). The Cullinan mine is still largely active and stands as the world’s second largest indicated diamond resource and is the only significant source of the extremely rare blue diamonds (Petra Diamonds, 2008). Data from Petra Mine’s estimates that the mine has produced more than 350 million tons of diamond yielding ore and has reprocessed more than 75 million tons of coarse tailing with more advanced recovery methods (Mining Technology, 2017).





REFILWE  
POPULATION : 19757

PROPOSED SITE  
OPEN LAND

DAM No. 7  
80,000,000 m<sup>3</sup>

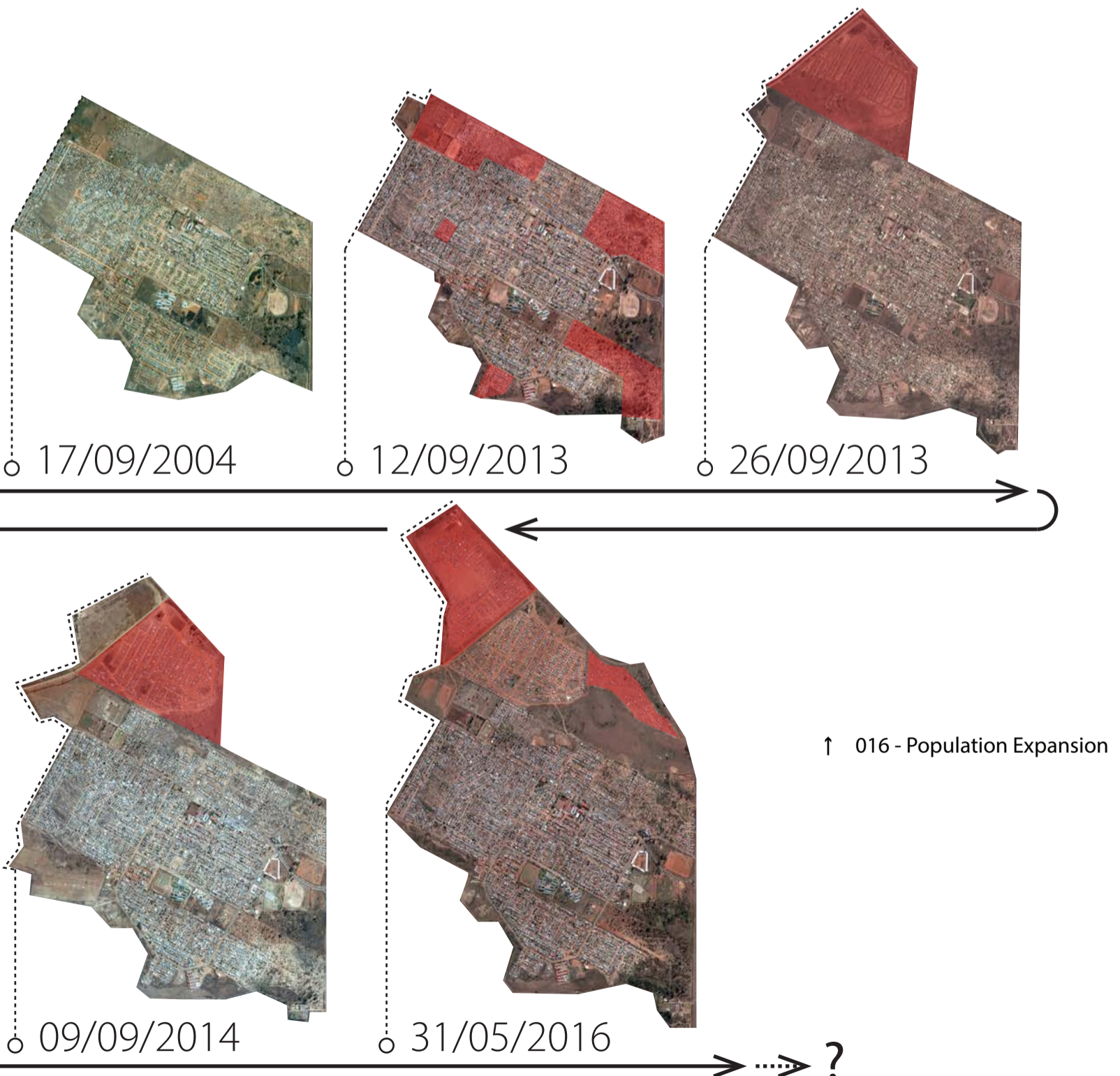
MINE COMPOUND  
319702 m<sup>2</sup>

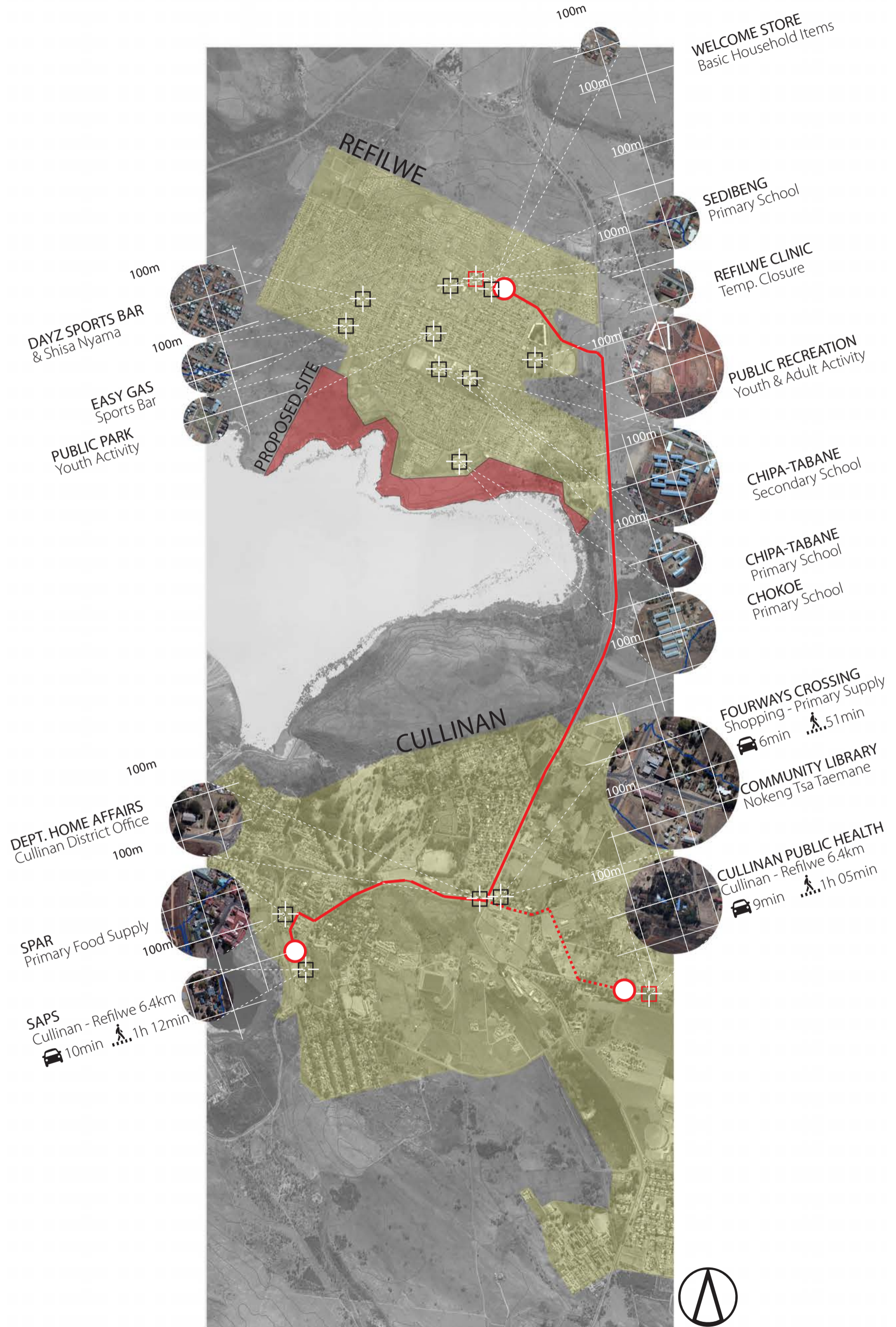
CULLINAN  
POPULATION : 8693

## 2.2// THE HIDDEN EFFECT

The Cullinan mine relies primarily on unsustainable methods of extraction of non-renewable resources. The Petra Diamond Group states their adherence to South African environmental laws, regulations and requirements, including the following acts: Mineral Resources and Petroleum Development Act (MPRDA) of 2002, the National Environmental Management Act (NEMA) of 1998. The reality of the matter is that these documents are outdated and do not provide adequate enforcement in protecting the direct mine landscape and surrounding landscape.

In recent years numerous research papers have delineated the adverse effects of mine related, waterborne, pollution on both the environment and communities situated in close proximity to slime dams. The deleterious effects of the mining related pollution are both a present-day and future problem. Refilwe, as delineated in Chapter One, was formed as a result of pre Apartheid laws. Refilwe's location was chosen as it provided adequate distance between the white residents of Cullinan and the black laborers of the mine. As appalling as the reasons for its locational placement, Refilwe has the additional ill-fated situation of being located in the expansion path of Cullinan Mine's slime dam no. 7. The viability of Cullinan and Refilwe's survival, once the mine is closed, depends both on the sustained ability of the mine to attract visitors and the health of the communities which currently serves it. It is estimated that the viability to mine the Cullinan kimberlite ore pipe will become economically unviable by 2059. International examples show that the closure of mines results in diminished interests in rehabilitation by mining companies, due to costs and reduced overall involvement in the area (Reynecke, 2011). Refilwe, with a population of almost 20 000 in 2017, equates to roughly double that of Cullinan's population. Aerial photos of Refilwe shows drastic expansion over the last 12 years and with only an estimated 42 years of viable mining left, yet the expansion of Refilwe could be exponential. This poses major problems for its population when the mine inevitably closes.





↑ 017 - Existing Infrastructure

## 2.3// THE MINE ISSUE

Mining and quarrying makes up a total of 9.2% of South Africa's industry (Statistics South Africa, 2012). This large percentage of mining industry has led to numerous mine sites being located in close proximity to human populations. This proximity is primarily due to the influx of people into mining areas, searching for better ways to make a living. In some cases this has resulted in the expansion of mining towns into large cities, such as Johannesburg. It is most often the less affluent of society which locates themselves the closest to mining sites, due to the cost of transportation and cost of land.

Communities, such as Refilwe, are left with limited solutions to managing the influx of pollution into their direct areas of livelihood and treating the associated health problems. The Refilwe community is set as close as 13m away from slime dam no. 7 of the Petra Diamonds Cullinan mine. Research has revealed the poor quality of water within this dam, including excessively high pH levels and a high dissolved salt content (Strydom, 2015). Case studies have shown the negative impact of mine related pollution, not only with concerns to community health, but also agriculture and livestock.

The National Nuclear Regulator (NNR), as early as 2010, started to warn local farmers not to allow their animals to drink from, or irrigate crops with, water from polluted areas. "The radioactive contamination of surface-water bodies in the Wonderfontein-spruit catchment is caused by long-term mine water discharges, runoff and diffuse emissions of seepage from slime dams" (Durand, Liefferink and Van Eeden, 2009). It must be noted that the pollution spoken of above, is due to gold mining and not diamond mining. It merely serves as an example of how detrimental mining can be to an area. Diamond mining related pollution is extremely different to gold mining and will be discussed in more detail in Chapter 3.

MINING ACTIVITY

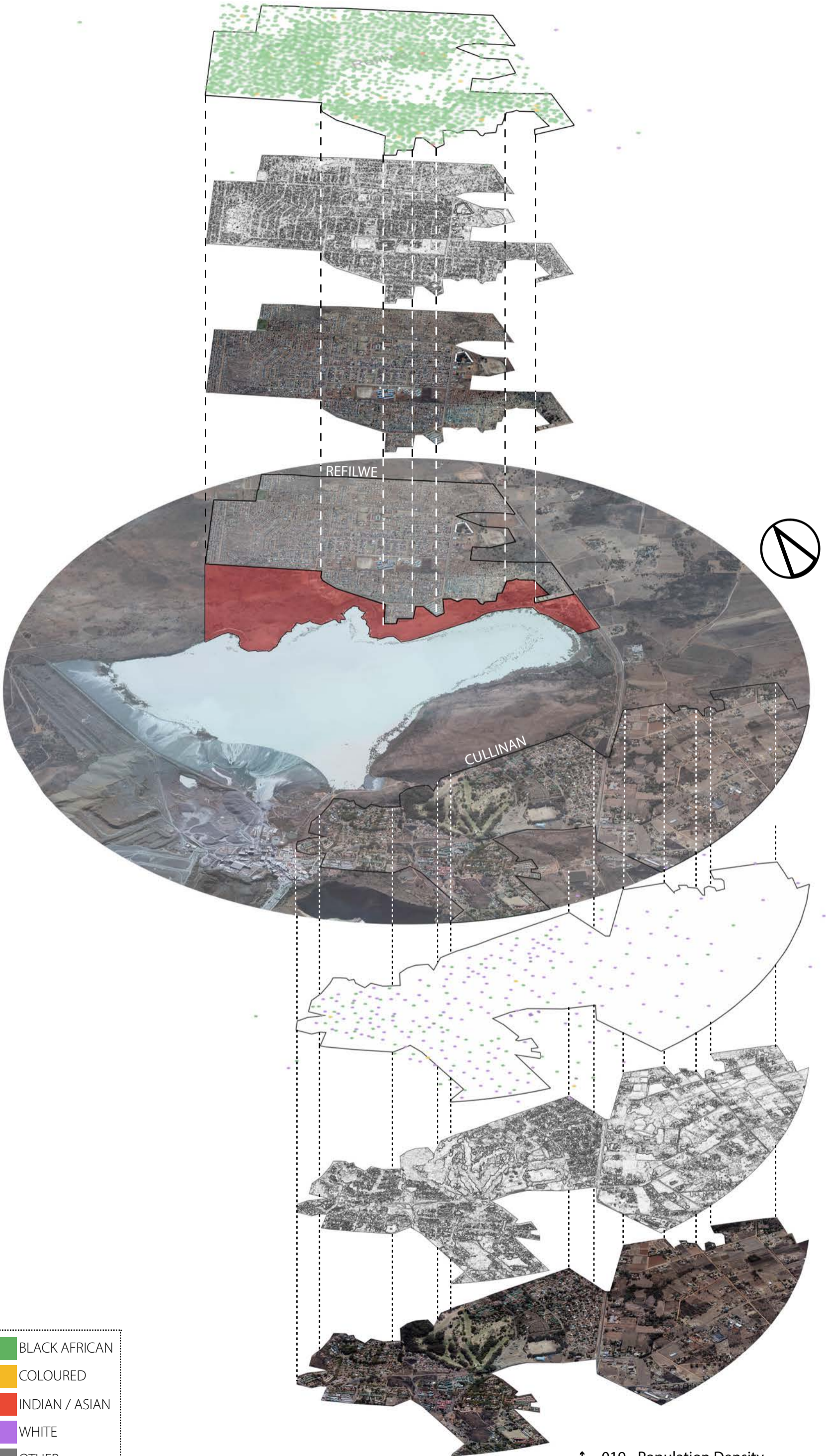


WONDERFONTEINSPRUIT



018 - Wonderfontein-spruit Pollution







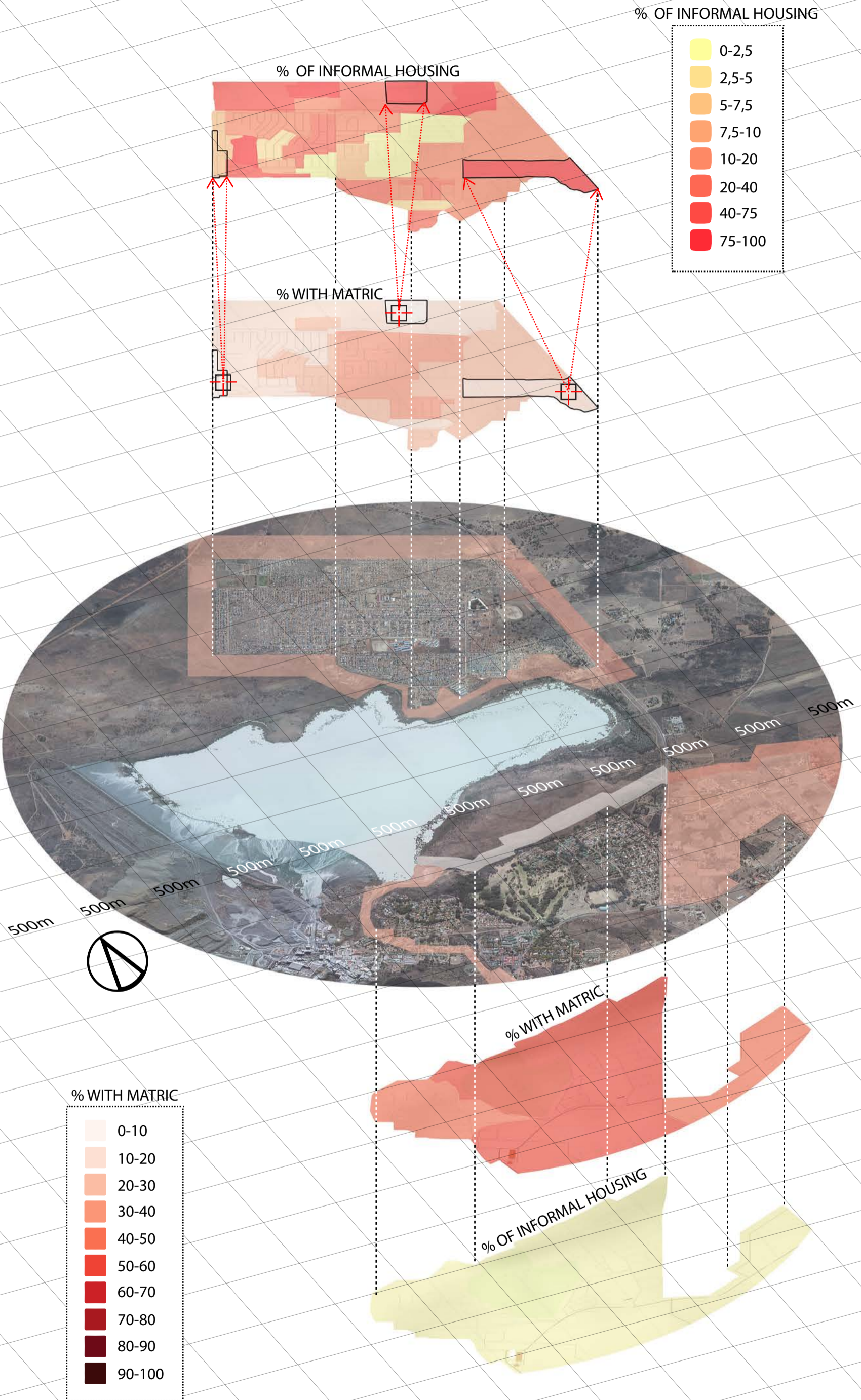
## 2.4// A FACTOR OF PROXIMITY

The constant expansion of Refilwe, as illustrated in Figure 016, is partly due to the continued success of the Cullinan mine and linked businesses. There are certain factors of this population expansion, which are of importance, when considering Refilwe as a possible site for architectural intervention. Refilwe's expansion is inhibited by two main factors; the no.7 slime dam and privately owned agricultural land. The slime dam exists as an insurmountable landscape barrier, which leaves Refilwe the option of expansion into lands lying primarily to its Northern edge. The use of these areas also have their own set of complications, as most of the land to all sides of Refilwe; North, East and West; are privately owned. One would then have to conclude, that it would be unwise to use precious space within Refilwe for new architectural interventions, which do not directly offer the possibility for housing.

The land between Refilwe's Southern edge and the no.7 slime dam exists as a permanent dividing line. The land is owned by the Petra Diamond Company and is currently fenced off. There are two main reasons for the fence between the slime dam and the Refilwe community: One is the protection of mine-owned land and the second is protection of the community from the polluted water. The fence line has been a more recent addition to the site and was not there, with unfenced perimeters as late as the early 2000s. This thesis proposes that the Petra Diamond company forms part of the architectural project, by becoming the main client. The inclusion of the Petra Diamond Company into the list of clients, would be both beneficial to the rehabilitation of the mine environment and beneficial to Petra Diamond themselves as it would help with the eventual rehabilitation of the site, which forms part of their government enforced closeout strategy (Sustainability Report, 2016; Petra Diamonds, 2017). Petra Diamonds' involvement would allow for the removal of the fencing if the architectural intervention tackles the aforementioned reasons for the fence line's existence. The illustrated ground between Refilwe and the no.7 slime dam edge would be a prime location for the proposed architectural intervention, which aims to rehabilitate both the no.7 slime dam and the community. This could eventually be rolled out for all the slime dams in the area.



Figure 019 to the left illustrates the continued effect of racial segregation from pre-Apartheid and Apartheid laws. There is a clearly visible racial division between Cullinan and Refilwe. The effects of this racial, and cultural divide are evident, considering the recent, and continual acts of xenophobic discrimination and violence in the area.



## 2.5// INTERNATIONAL CONTEXT

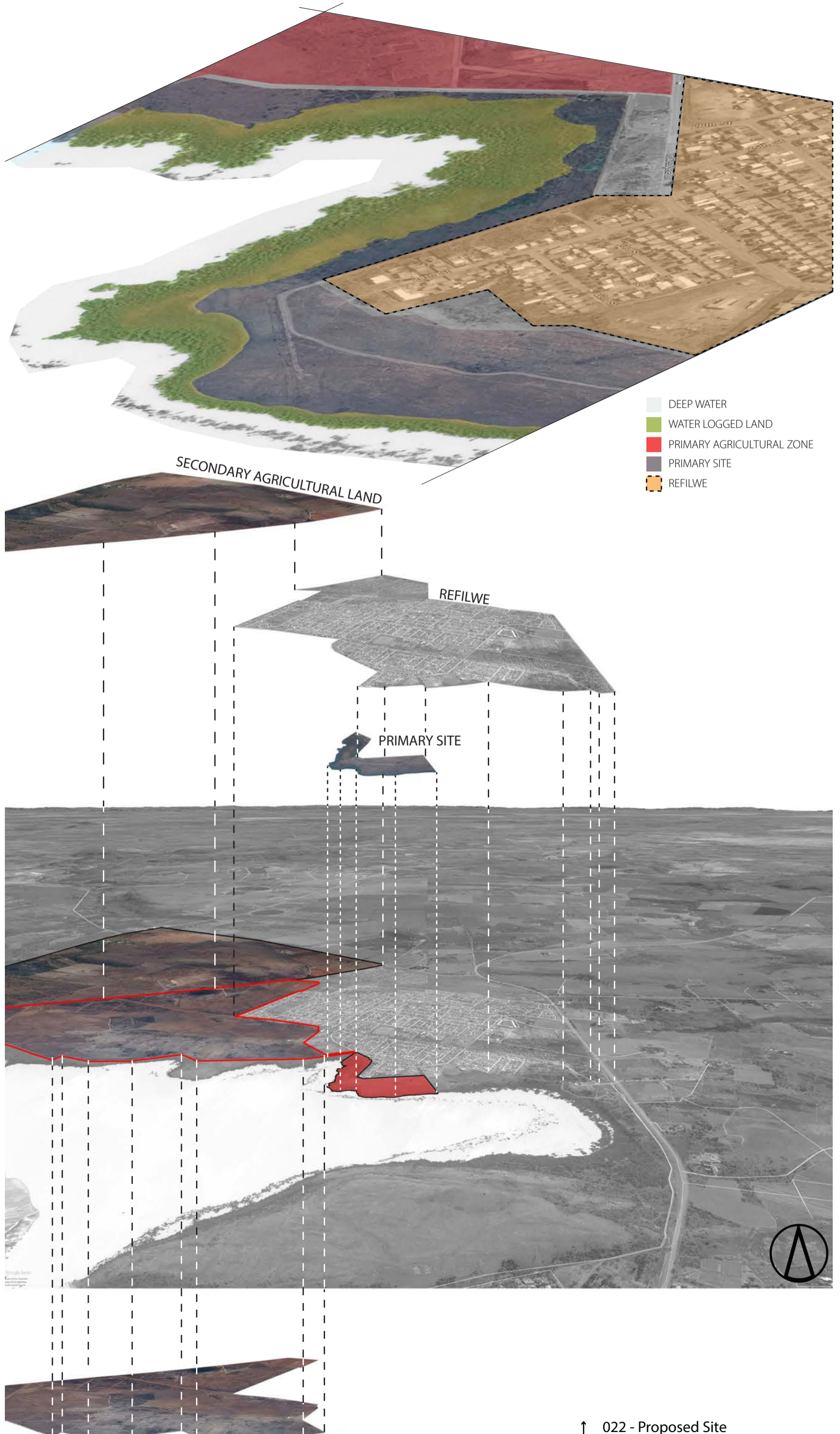
The negative effects of ill prepared mine closures is an international problem, especially in developing countries. Ultimately, mine closure is inevitable for any mine. Due to this, it has become increasingly important to structure the process of mine closures from as early on as the mine design stage (World Bank and International Finance Corporation, 2002). The process of mine closure is an increasingly complex process, encompassing much more than mere technical solutions. Today mine closure involves not only mining companies but also includes governments, specialists and communities connected to mines. It is imperative that local communities are proactively involved in eventual mine closure to ensure the benefits reaped from the all processes; including secondary programs; involved in mining, during the course of mining, are sustainable for future generations. For the process of mine closure to be successful and completed wholly, governments must provide strict and up-to-date legal frameworks to ensure no large scale environmental or social problems are left solely up to them.

When mine closure happens incorrectly or abruptly, due to unforeseen and sometime uncontrollable circumstances, it can cause significant liabilities for both mining companies and governments. More often for governments than for mining companies, as ultimately, a mining site is the responsibility of a government if a mining company, were say, to dissolve. The liabilities imparted onto a government, due to improper closure plans, can include significant costs which are often unpayable for developing countries governments. Unfortunately the reality at hand is that even with a successful mine closure, the severe reduction in incomes within a community can cause great socio-economic strain. With an improper mine closure, the effects can be much more severe, on both social and environmental spheres. The aforementioned information does not even begin to consider the implications of mine related pollution on both the environment and community health.

In the past, mines were often merely abandoned after they became economically unviable. This historic trait, unfortunately, still occurs today in some developing countries where governments do not have sufficient policies or frameworks in place. Often the benefits of a monetary influx, associated with mining, is considered of more importance than negative consequences due to damage of the environment or social health.

It has become abundantly clear that it is of the utmost importance that the socio-economic and long lasting environmental damage of mine closure; and the impact this has on employees, their families and the general mining community; must be mitigated.

*“For mining communities, mine closure can cause severe distress because of the threat of economic and social collapse – possibly of an entire region.”* (World Bank and International Finance Corporation, 2002)



## 2.6// A FACTOR OF WATER QUALITY

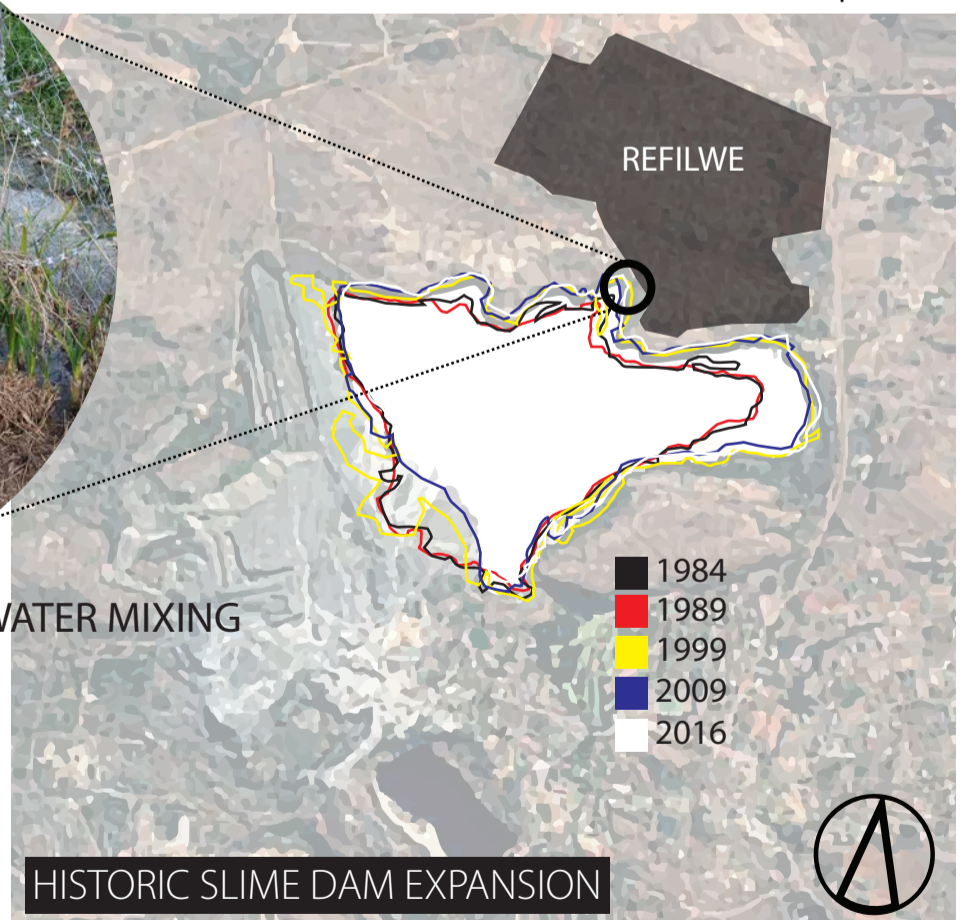
*"The crisis of urban water quality and quantity is becoming so acute, that many are recognizing it as a pronounced environmental problem, making the protection and regeneration of this natural resource paramount to the resilience of Pretoria." (Peres, Barker and du Plessis, 2015)*

Water quality is often taken for granted in urban areas in South Africa, yet to many, clean water is not a given. The acute pollution of natural water supplies, due to mining activities, is greatly concerning. The outlook for the future of the Cullinan area shows very little planned rehabilitation efforts, beyond the closeout procedures of Petra Diamonds, which focuses primarily of the direct mine landscape. Cullinan and its surrounding landscape historically served as an agricultural zone. Even today the surrounding area is host to numerous and varied zones of agriculture. The supply of quality water is inarguably the most important factor in sustainable farming. One of the major concerns with a water mass such as slime dam no.7 is the possibility of chemical seepage into natural water sources. The dangers of chemical seepage has become a serious problem in many mining areas. One example is the toxic seepage of gold mine related chemicals into water supplies of Johannesburg. This is illustrated in figure 018 which shows the proximity of chemically saturated areas to the Wonderfontein spruit, an important supply of water to the area. Research has shown the influence these chemically saturated areas have already had on the greater Johannesburg water supply (Durand, Lieferrink & Van Eeden, 2009). The exact chemical composition of slime dam no.7 is still unclear and thus the repercussions of seepage into surrounding water supplies is still largely unclear. This thesis and architectural design aims to establish a laboratory programme to investigate the exact chemical composition of slime dam no.7 and ways to rehabilitate the polluted waters and surrounding landscape surrounding the Refilwe community. The proposed architectural intervention will stand as a point of focus for possible rehabilitation methods which can be applied to the Cullinan mine and to similar mining sites. It is of the utmost importance that the architectural and programmatic intentions are achieved before the closure of the Cullinan mine, due to the eventual flooding of the Cullinan Hole, through accumulating rainwater. The hole is approximately 1km long, 0,5km wide and 0,45km deep with a volume of 225 000 000 cubic meters. This is roughly 2.5x the capacity of dam no. 7 . The full detrimental impact already being caused by dam no.7 is still largely unknown, as previously stated, but the addition of the Cullinan Hole as a site of polluted water could be catastrophic if a viable solution is not established.



SEWAGE LEAKAGE AND SLIME DAM WATER MIXING

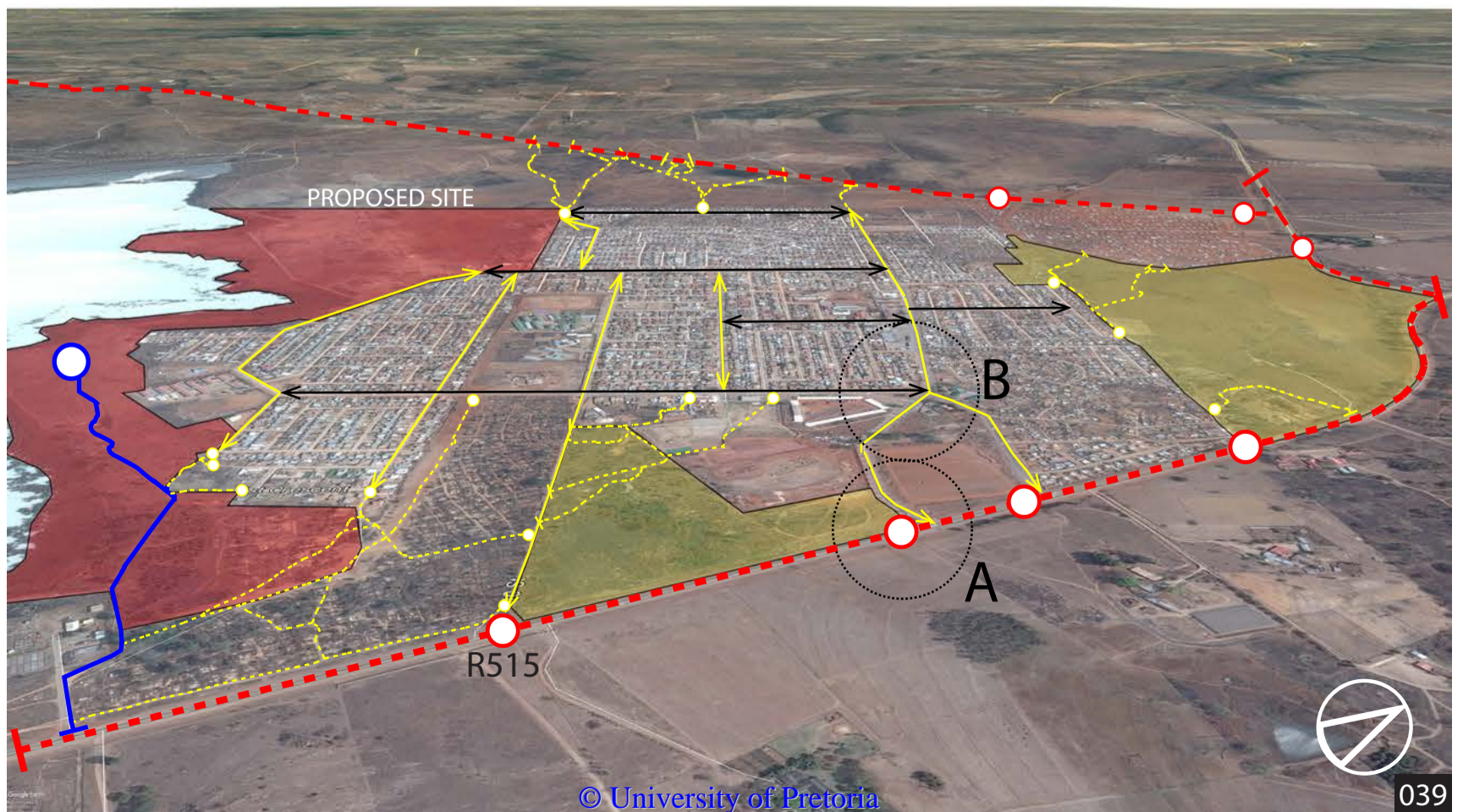
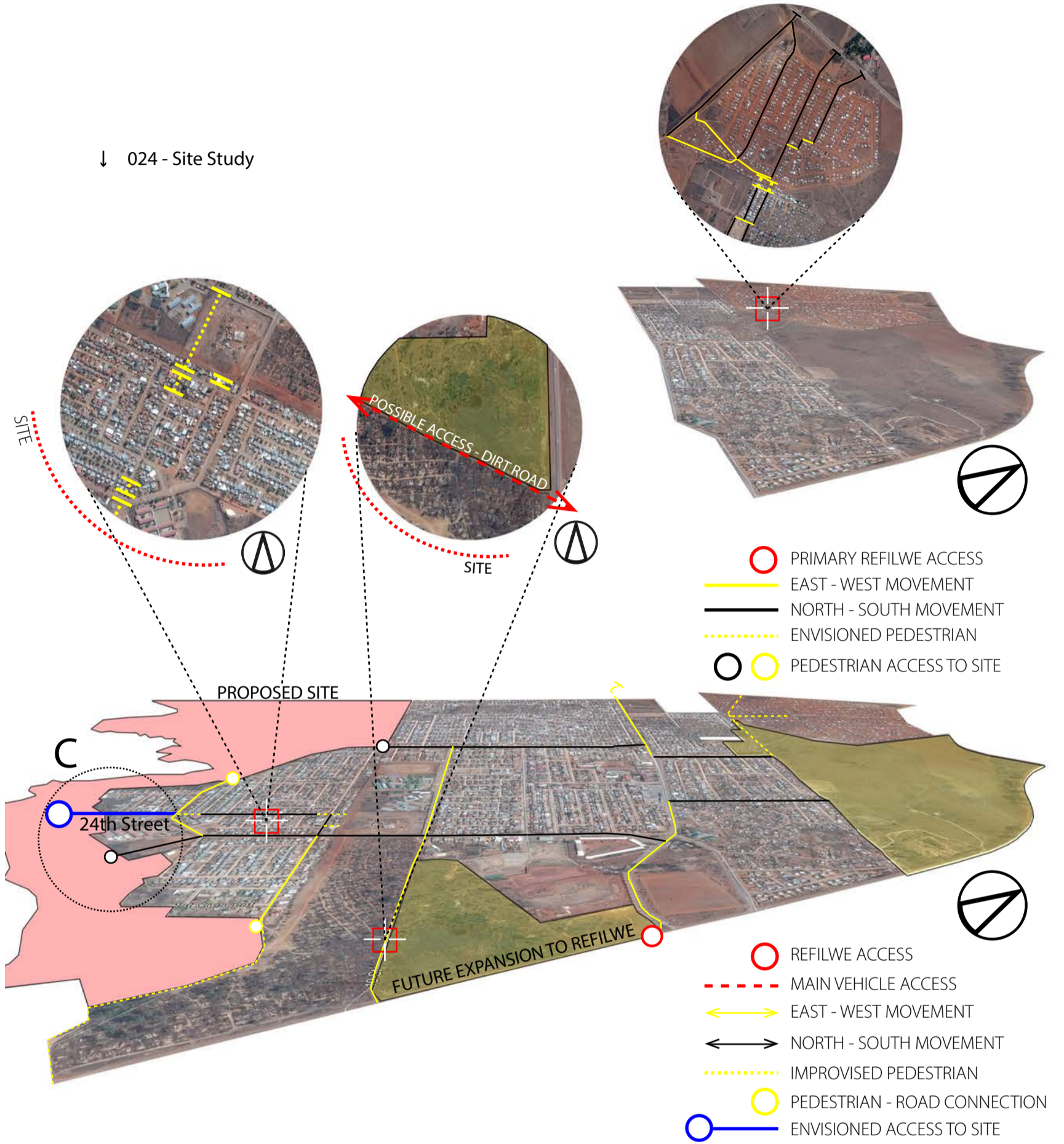
↓ 023 - Historic Slime Dam Expansion



HISTORIC SLIME DAM EXPANSION

The no. 7 dam has an approximated total volume of 80,000,000 cubic meters (Miller, Van Den Bossche and Slogrove, 2008) and is estimated to reach its maximum capacity well before the expected closure date of the mine. The proximity and extent of the used capacity cause extensive concerns of polluted water seepage and spillage.

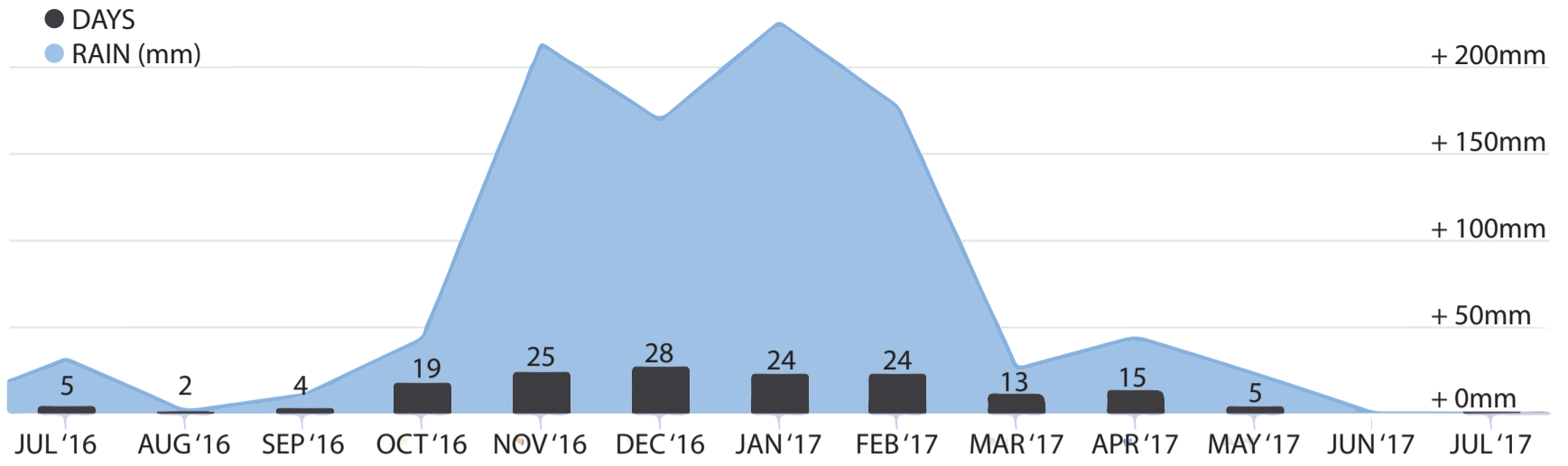
↓ 024 - Site Study



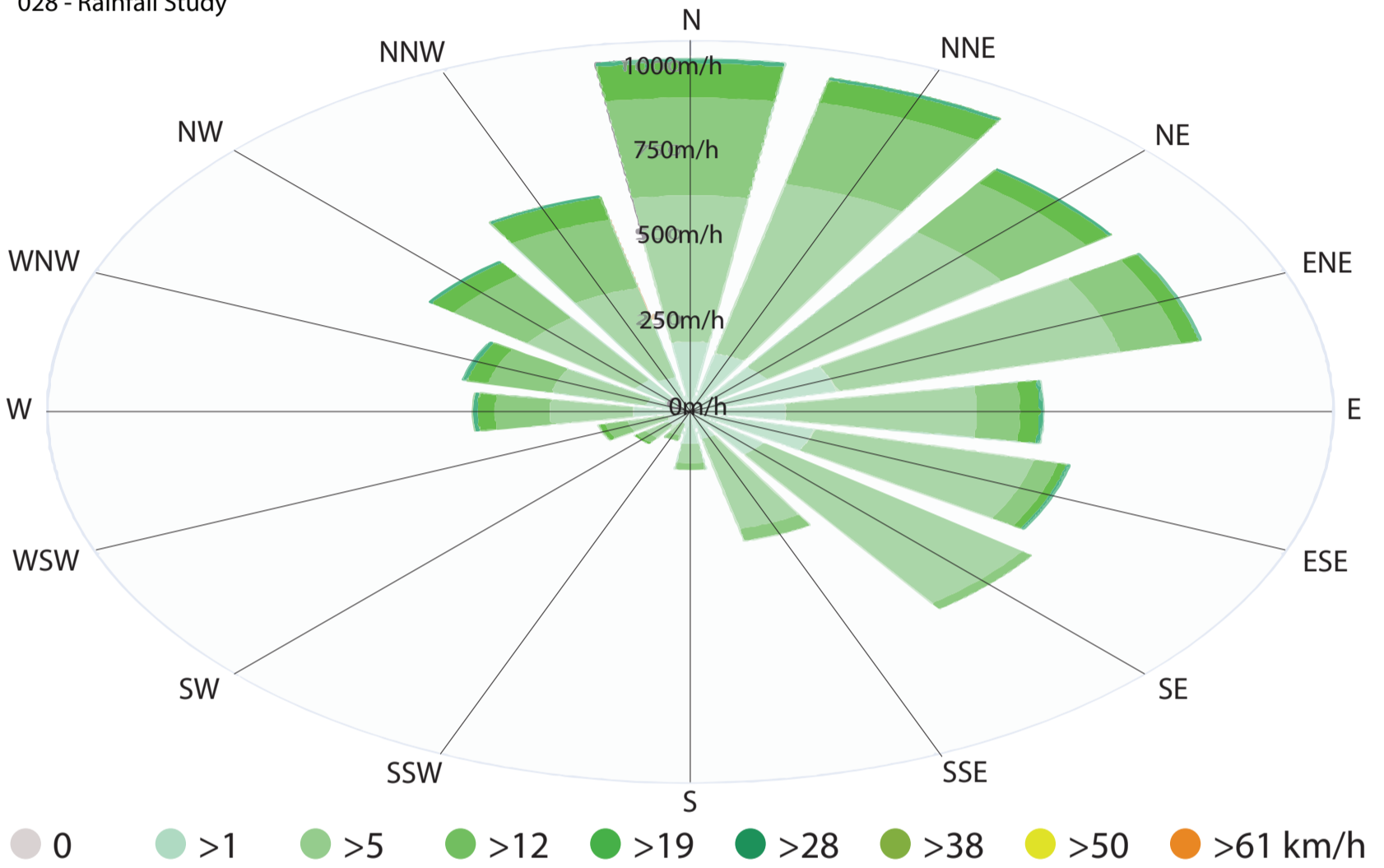
## 2.7// ACCESSIBILITY

Refilwe's roadways spawned almost as organically as the town did. Certain areas within Refilwe exemplify traditional road and property layouts and some areas show pure organic expansion with roadways merely connecting haphazardly placed infrastructure and housing. As previously mentioned, the 'Game of Diminishing Returns' architectural intentions aim to remediate the Refilwe community in numerous ways. Due to the small plot sizes and density of Refilwe, it would be an inappropriate response to build large accessibility infrastructure through Refilwe to the intended site. I thus propose the use of an existing auxiliary road, indicated in the illustration to the left. The proposed road exists physically as a dirt road and programmatically as an access way to check the integrity of the Petra Diamond Mine Complex fence line. The proposed architectural programme intends to react to the existing site and will try to not impose permanent physical change, where possible. Thus the intended access road will be left as a dirt road. The proposed site can also be accessed through an existing tar road, 24th street, which will serve as a pedestrian access point for employees from Refilwe. Vehicular access will be programmatically less important due to the architectural programme intending to use the local community as a labour force. Vehicular access and parking will be predominantly for occasional visitors, visiting or employed professionals who would commute to the site and service vehicles.

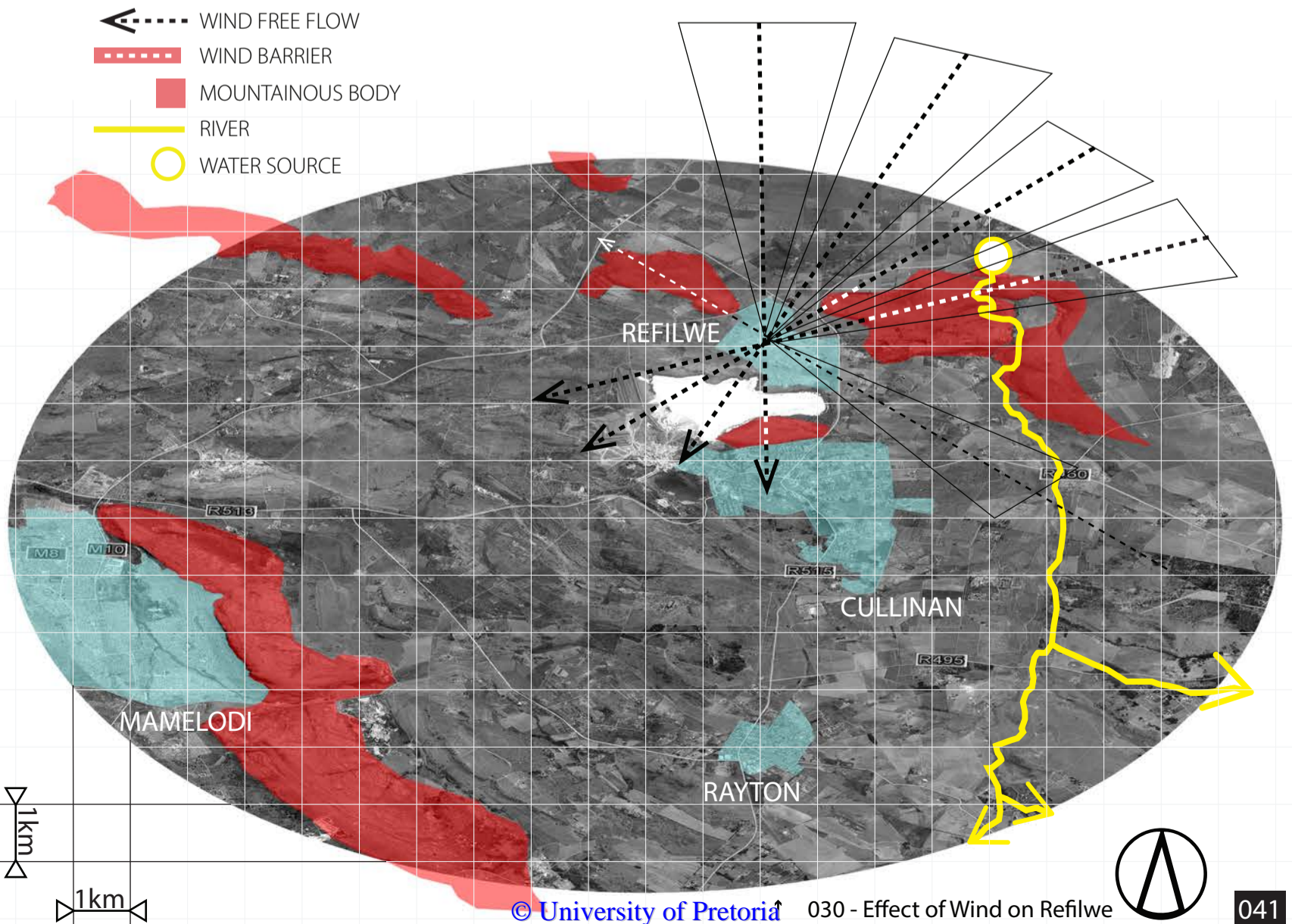




↑ 028 - Rainfall Study



↑ 029 - Average Wind Speed Study





## 2.8// ENVIRONMENTAL INFLUENCES

There are two major factors which could have environmental impacts on the proposed site and surrounding areas. Those factors are average rainfall and average wind speeds. Each of these factors could have contributing elements to the future success of the Cullinan area, after mine closure.

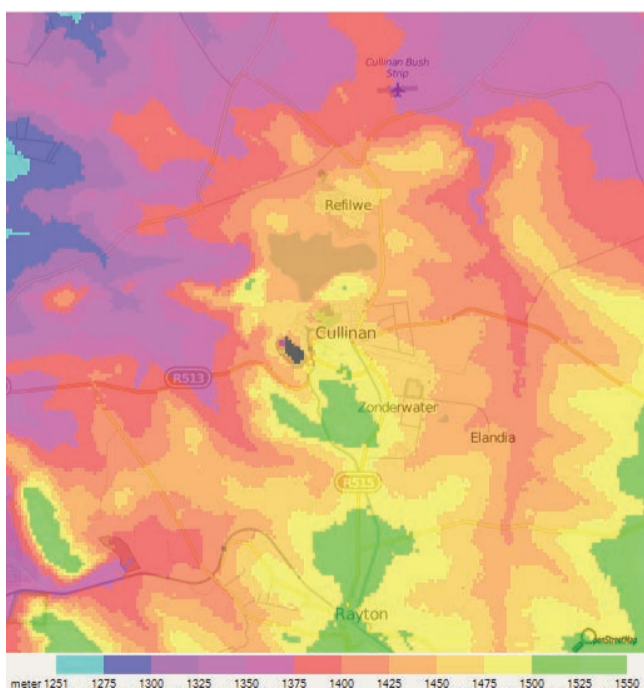
Average rainfall would influence the water levels of both slime dam no.7 and the Cullinan Big Hole. Due to the relatively small surface area of the Cullinan Big Hole comparatively to its depth, it is most likely that it will eventually fill with rainwater and remain submerged even with evaporative factors. This estimation has historic backing, during mine closure caused by the great depression (1932), the Cullinan Big Hole did fill with water. It was dewatered 13 years later in 1945 to allow for continued mining efforts.

The large surface area of the no. 7 slime dam comparatively to its depth would suggest that the majority of its water would eventually evaporate. This could cause extensive environmental damage due to wind blowing dust particulates great distances. These particles could contain hazardous chemicals and could affect agricultural lands to the southwesterly direction of the slime dam. With high enough wind factors, one could estimate that these chemically rich dust particles could even reach Mamelodi, effecting its residence in indeterminate ways. These effects could possibly be detrimental to the residence of Mamelodi, not to mention the agricultural areas in between. The aforementioned predictions informs the role that bioremediation of the slime dam could play in protecting the greater Cullinan area from harm.

Elevation maps displaying information about the areas range of elevation. Data was generated using elevation information from NASA's 90m resolution SRTM data.

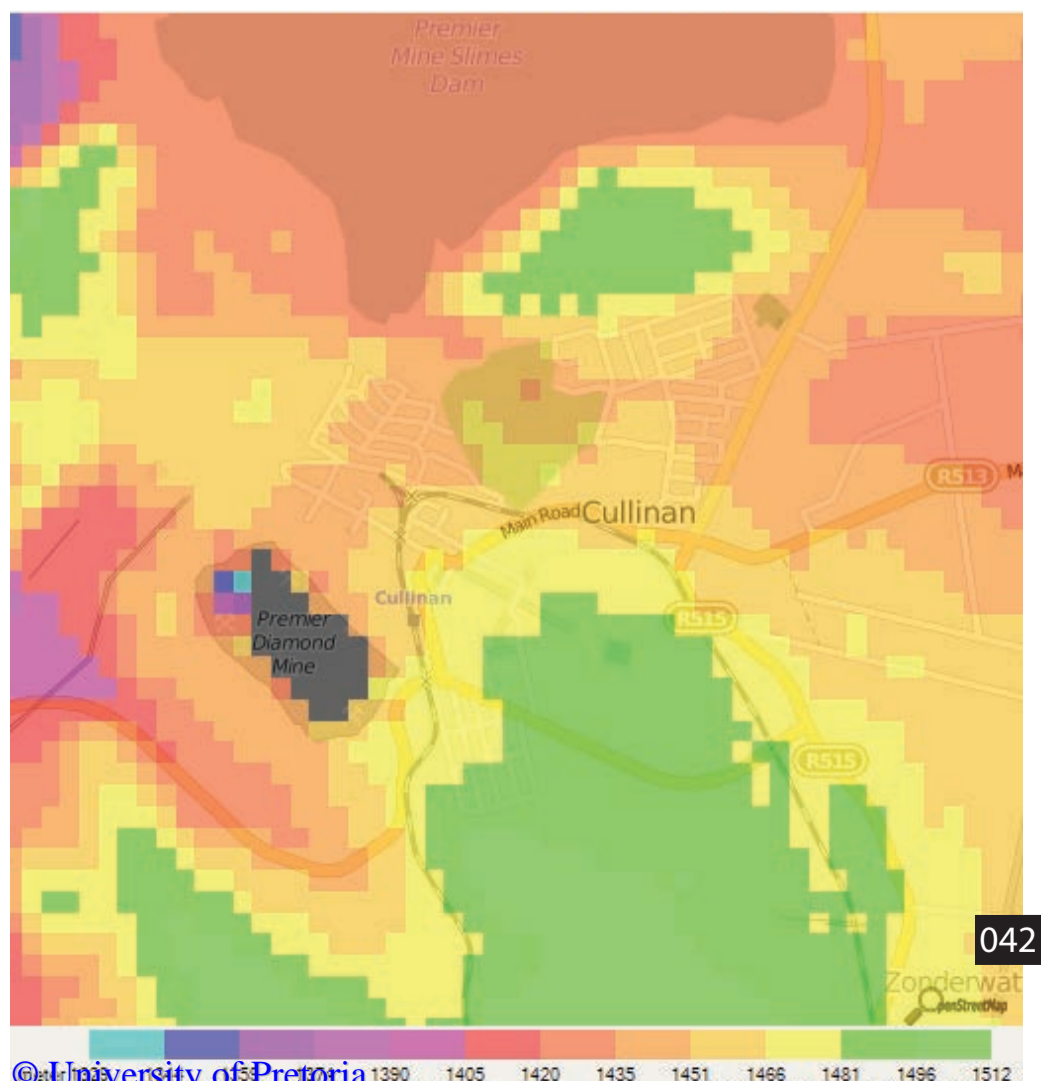
This information provides valuable data on physical wind barriers and contour information pertaining to the proposed site and greater surrounding area.

↓ 031 - Elevation Data. (Panel, 2017)



Elevation maps displaying information about the areas range of elevation. Data was generated using elevation information from NASA's 90m resolution SRTM data.

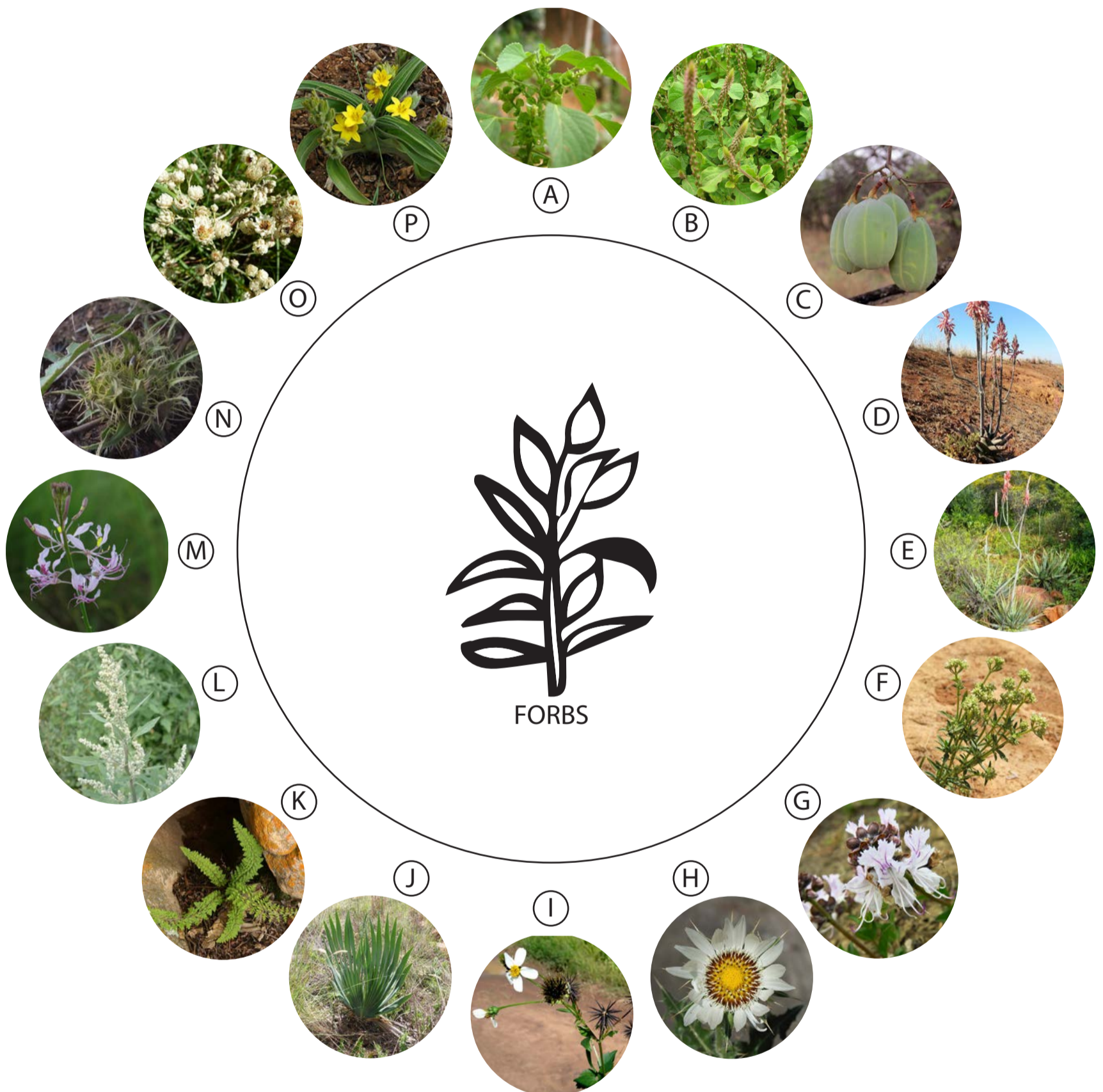
This information provides valuable data on physical wind barriers and contour information pertaining to the proposed site and greater surrounding area.



## 2.9// BIOREMEDIATION

Bioremediation has proven to be one of the most effective methods of mine related landscape rehabilitation. Forbs and grasses from the local area could be used to absorb chemicals from slime dam no.7. This process will be further discussed in subsequent chapters and will form an integral part of the architectural programme. The 'Game of Diminishing Returns', and its laboratory programme will include research into the effectiveness of various plants to absorb on site chemical contaminants. Internationally certain forb and grass species have shown great resilience to chemicals, from mine related industry, and an ability to absorb and nutritive them. The use of these plants would be beneficial as an initial rehabilitation method, but the eventual goal would be to exclusively use plants from the proposed site. This will be tested and proven either viable or unviable by the proposed laboratory programme.

### ↓ 032 - Bioremediation Forbs / Onsite Plant Study



(A) ACALYPHA INDICA

(B) ACHYRANTHES ASPERA

(C) ADENIA DIGITATA

(D) ALOE DAVYANA

(E) ALOE PRETORIENSIS

(F) ANTHOSPERMUM HISPIDULUM

(G) BECIUM OBOVATUM

(H) BERKHEYA SEMINIVEA

(I) BIDENS PILOSA

(J) BOOPHONE DISTICHA

(K) CHEILANTHES HIRTA

(L) CHENOPODIUM ALBUM

(M) CLEOME MACULATA

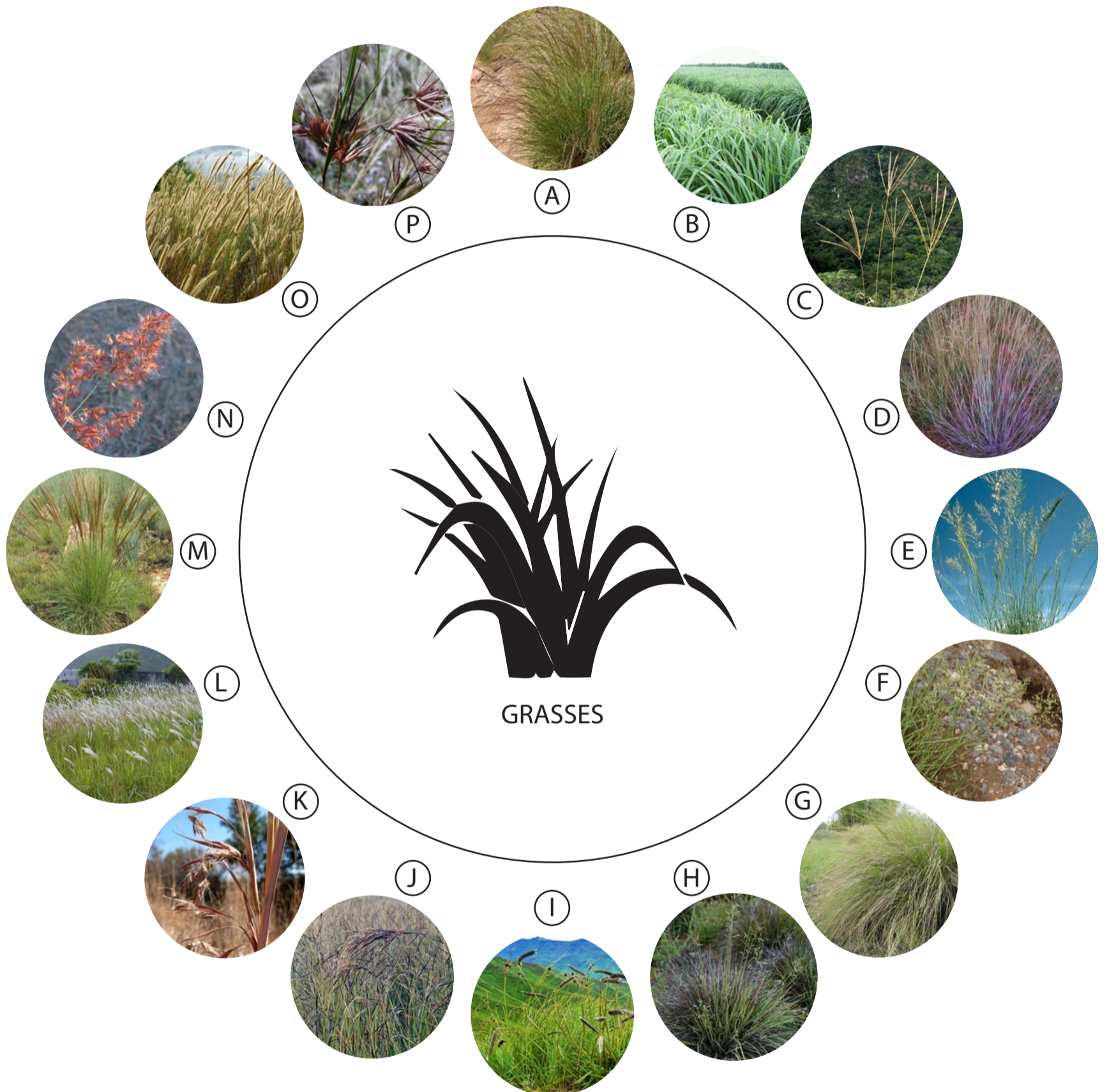
(N) CRABBEA ANGUSTIFOLIA

(O) HELICHRYSUM RUGULOSUM

(P) HYPOXIS HEMROCALIDEA

The Game of Diminishing Returns laboratory programme will investigate the potential use of plants used for remediation purposes. This is important as the absorption of chemicals, by the forbs or grasses, may render them unusable due to retaining the aforementioned chemical pollutants. This research will be of the utmost importance with regards to agricultural crops. If agricultural crops could be used for remediation purposes, while neutralizing the absorbed chemical pollutants, and not merely storing them, it could be greatly beneficial to the Refilwe community. Many of the forbs and grasses illustrated have various local uses; medicinally, aromatically and physically as building materials. The simultaneous production of edible, medicinal, aromatic or building material crops, and their possible chemical neutralization, could offer incredible benefits not only to the Refilwe community but to many communities around the world, who are affected by mining related pollution.

↓ 033 - Bioremediation Grasses / Onsite Plant Study



(A) ARISTIDA TRANSVAALENSIS

(B) CYMBOPOGON VALIDUS

(C) DIGITARIA ERIANTHA

(D) DIHETEROPOGON AMPLECTENS

(E) ERAGROSTIS CURVULA

(F) ERAGROSTIS LEHMANNIANA

(G) ERAGROSTIS CURVULA

(H) ERAGROSTIS RACEMOSA

(I) HARPOCHLOA FALX

(J) HETEROPOGON CONTORTUS

(K) HYPARRHENIA HIRTA

(L) IMPERATA CYLINDRICA

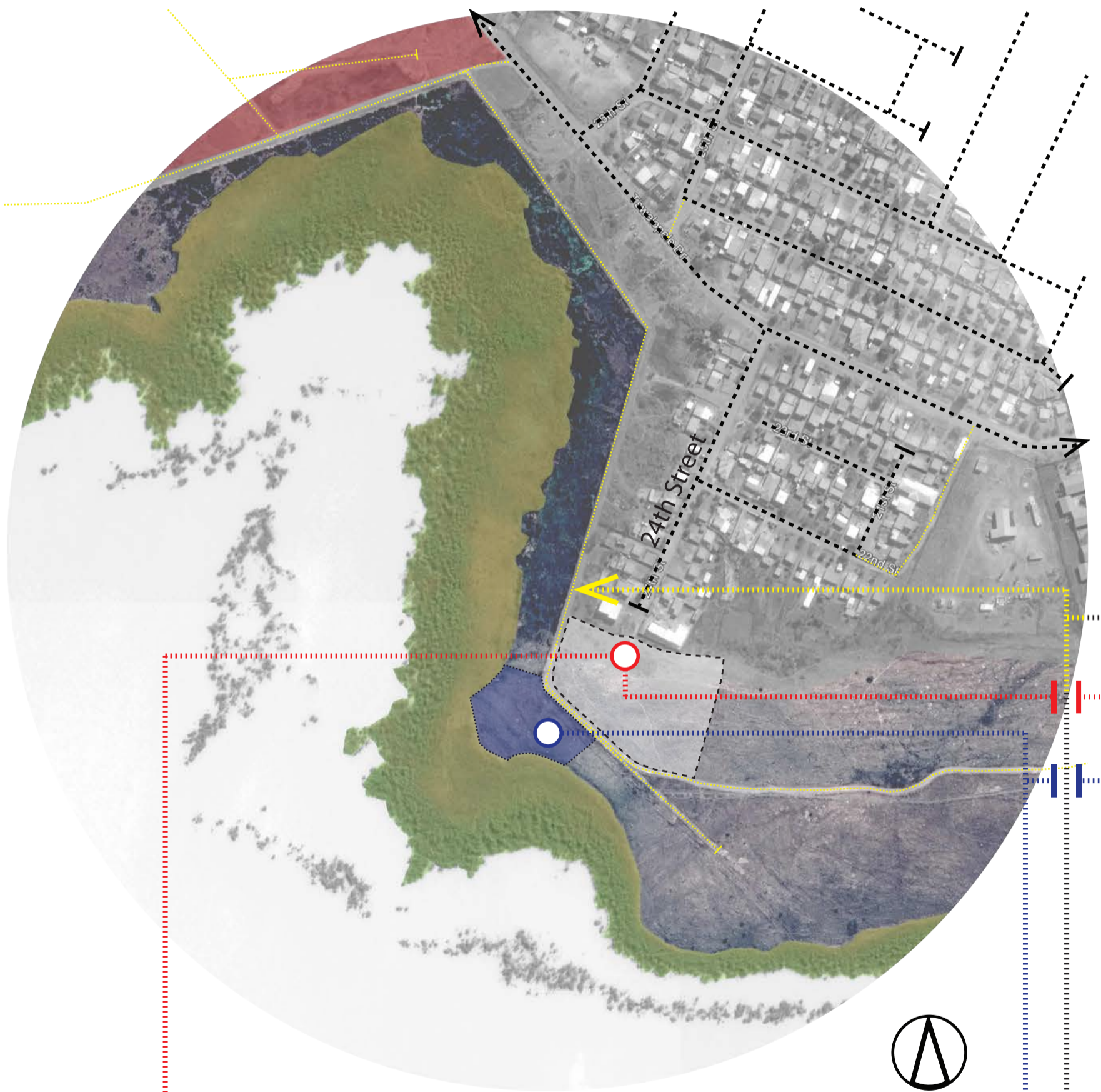
(M) LOUDETIA-SIMPLEX

(N) MELINIS REPENS

(O) SETARIA SPACHELATA

(P) THEMEDA TRIANDRA

2.10 // SITE ACCESS AND PHOTO STUDY



↑ 034 - Site Access and Photo Study



