AIS ENVIRONMENT

Appropriate Assessment for the Storm water relief tunnel upgrades to relieve flooding problems near Mater-Dei Hospital Roundabout

As per ERA requirements for PA/6860/21

Report

AIS ENVIRONMENT

APPROPRIATE ASSESSMENT

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1 EXECUTIVE NON-TECHNICAL SUMMARY

This Appropriate Assessment report describes the ecological impacts arising from the construction and operation of the proposed development (PA/6860/21). The development application proposes the "*Storm water relief tunnel to relieve flooding problems near Mater-Dei Hospital roundabout*".

The project, hereinafter referred to as the "Scheme", aims to reduce flooding and improve surface water runoff at the San Ġwann Industrial Estate, specifically at Triq Sir Anthony Mamo. This study identifies the hydrological and ecological features in the area and assesses the impacts caused in relation to the AA for the proposed development, in line with the requirements issued by the ERA under EA 00032/22.

2 PROJECT DESCRIPTION

The existing stormwater infrastructure in the area is inadequate to handle storm water runoff during moderate to heavy rainfall events. This results in flooding along Triq Sir Anthony Mamo and the San Ġwann industrial estate. The water then slowly discharges into Wied Għollieqa after flowing across Triq Sir Anthony Mamo and Triq San Ġiljan.

To address the flooding in the area, the proposed Scheme involves constructing an underground tunnel. This tunnel will connect with the existing Birkirkara Catchment Flood Relief Tunnel that is connected with the remining National Flood Relief Project (NFRP). The Scheme will collect stormwater runoff from the San Ġwann Industrial Estate and Ta'Żwejt Residential Area. The proposed tunnel will be approximately 600m long with an average diameter of 3.6m. Vertical access shafts will be constructed for inflow and access to/from the tunnel. Additionally, proprietary oil and grit separators will be installed before the tunnel entrance to treat the stormwater runoff and remove pollutants and silt. Thus, it is estimated that between 20-30% of the total catchment area shall be diverted into the NFRP tunnel.

FIGURE 1: FLOODING AT TRIQ SIR ANTHONY MAMO, AS MAPPED IN FIGURE 2

The catchment areas mentioned earlier are part of the Gżira Catchment, which is one of the main sub-catchment areas considered for the Preliminary Flood Risk Assessment (PFRA) in the Malta River Basin District. Flood mitigation infrastructure has already been built for the Gżira Catchment, including a soakaway reservoir with a capacity of around 10,000m^3 at the end of Wied Għollieqa and an underground tunnel connected to the Birkirkara-Ta' Xbiex tunnel for overflow discharge. The proposed tunnel extension is shown in red in Figure 1.

Since the proposed tunnel will collect runoff from the San Ġwann Industrial Estate and Ta'Żwejt Residential Area, it will reduce the size of the Gżira Catchment and subsequently decrease the amount of stormwater flowing into Wied Għollieqa. Consequently, the scope of this report is to identify how the diversion of stormwater away from Wied Għollieqa can influence the ecological dynamics of the site.

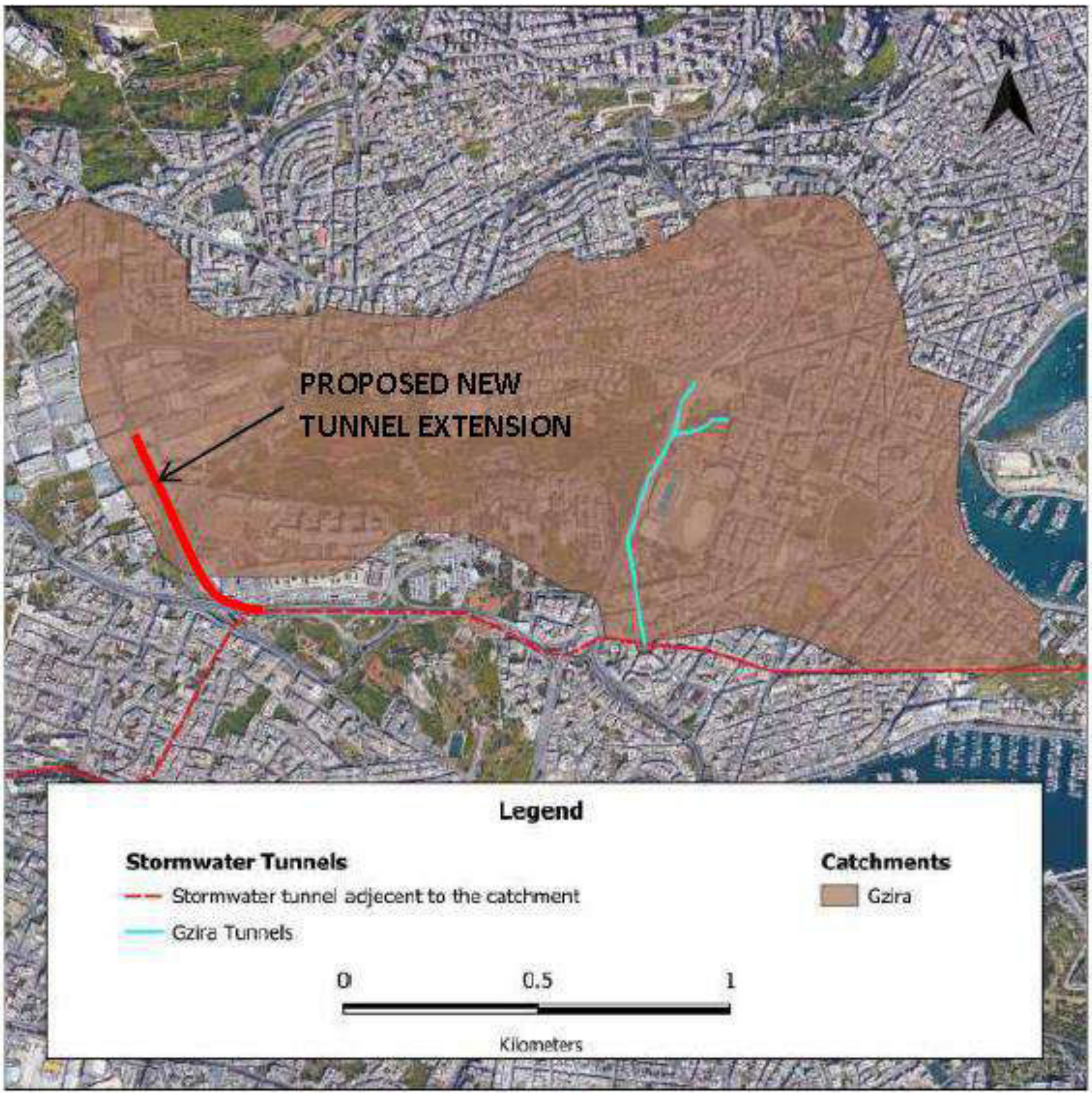


FIGURE 2: PROPOSED TUNNEL EXTENSION

The majority of the modifications to the site will occur predominantly within the confines of the street and at significant depths beneath its surface (c.40m). These alterations will remain inconspicuous when observed from street level. To execute the expansion of the tunnel, a tunnel boring machine driven by electro-hydraulic power will be employed. This specialized machinery possesses the capability to excavate the desired tunnel profile while minimizing vibration effects. This attribute renders it exceptionally valuable from both safety and environmental standpoints.

The prevailing tunnel boring machines used in the tunneling endeavors of Malta demonstrate a standard excavation productivity of approximately 7.6 cubic meters per hour, equating to an excavation length of roughly 8 meters per day for a tunnel with an approximate diameter of 3 meters. With the dimensions of the proposed tunnel taken into consideration, the anticipated quantity of rock to be excavated stands at approximately 4,800 cubic meters. Conversely, the vertical access shaft will be delved using a hydraulic piler mechanism, yielding an excavated material volume of around 125 cubic meters. This excavated material holds potential for collection, processing, treatment, and subsequent recycling. It can find applications as a lean mix material within the construction sector, serve as granular sub-base material in road construction, and even contribute to the fabrication of reconstituted stone blocks. These blocks, composed of durable, dense limestone material, can be hewn, shaped, and finished akin to natural limestone.

Considering the spatial constraints imposed by the tunnel and access shaft, the removal of the excavated material will necessitate the utilization of dumpers. The excavated material from the proposed tunnel will be temporarily stored in designated areas, whose location and establishment will be determined prior to project commencement. In due course, the material amassed within these areas will be transferred onto larger trucks and subsequently deposited in authorized dumping sites. In the case of the access shaft, the excavated material will be loaded onto dumpers for transportation to an approved dumping site.

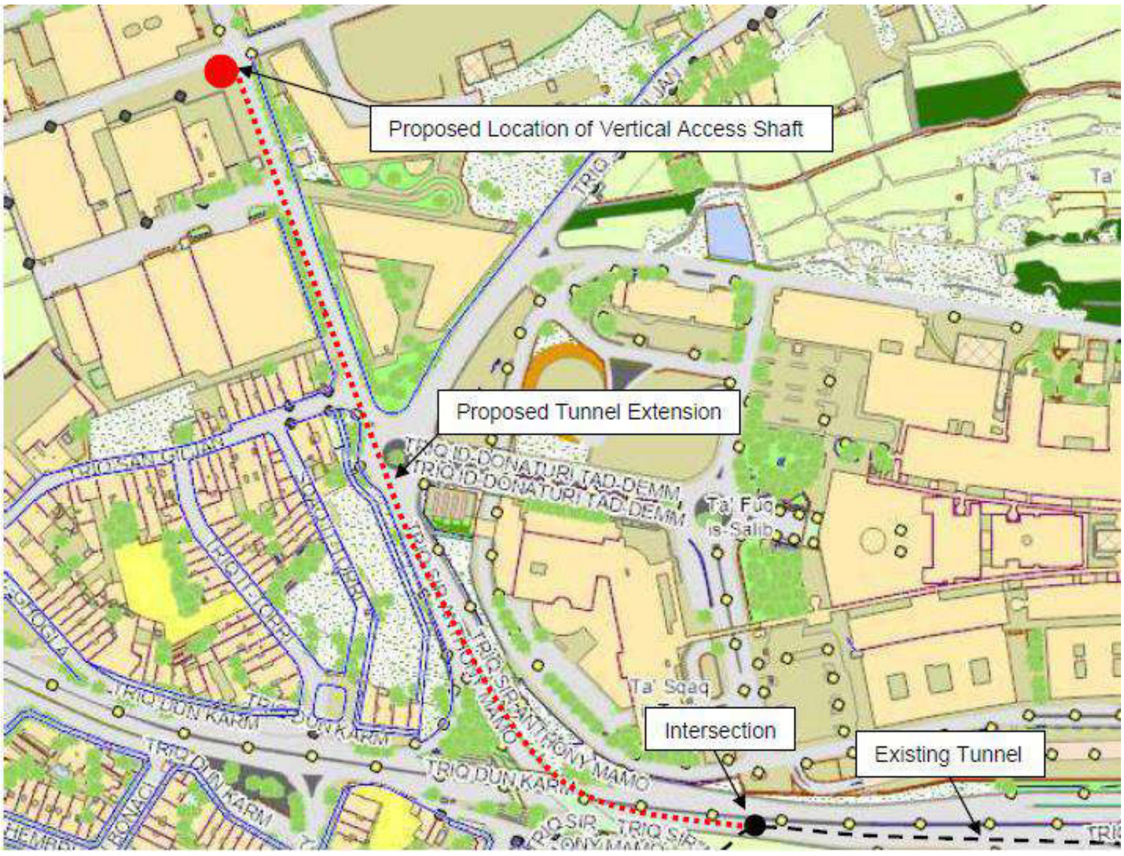


FIGURE 3: MAP SHOWING PROPOSED TUNNEL (RED) AND INTERSECTION WITH EXISTING SYSTEM (BLACK)

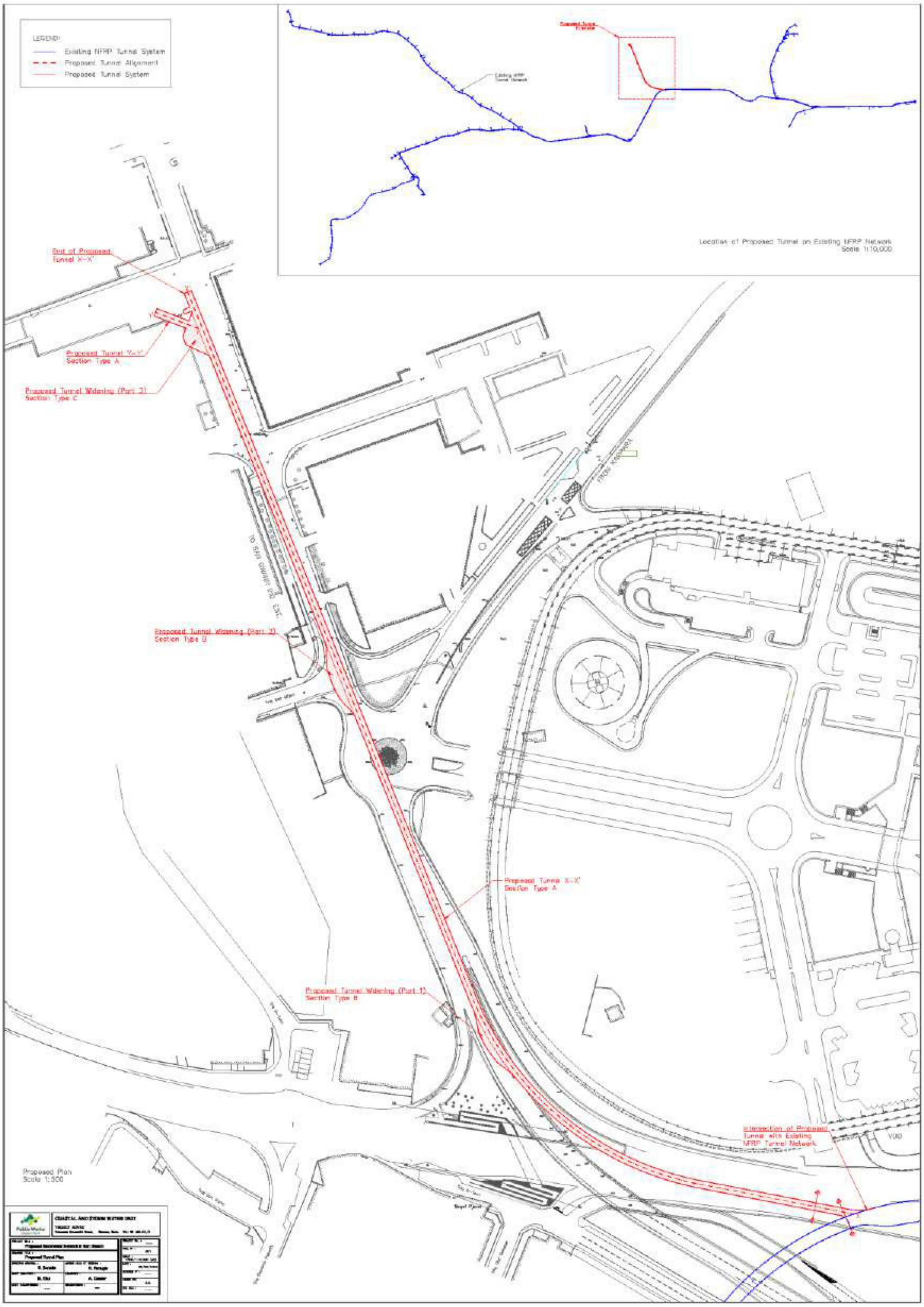


FIGURE 4: SCHEMATIC DRAWING OF THE PROPOSED INTERVENTION

2.1 STUDY METHODOLOGY

2.1.1 Hydrology

The hydrological study investigated the peak runoff generated and crossing Triq Sir Anthony Mamo and Wied Għollieqa at different rainfall intensities and recommendations were made to minimise the negative impacts on Wied Għollieqa through the proposed Scheme.

The Rational Method was used to determine peak discharges from small drainage areas. This mathematical method is traditionally used to size storm sewers, channels and other stormwater structures which handle runoff from drainage areas less than $50km^2$. The formula is expressed as:

$$Q = CiA$$

$where:$
$Q = peak\ rate\ of\ runoff\ (m^3/s)\ ;$
$C = runoff\ coefficient, representing\ relationship\ between\ rainfall\ and\ runoff$
$i = average\ intensity\ of\ rainfall\ in\ cm/hr\ \ for\ the\ time\ of\ concentration\ (Tc) for\ a\ selected\ frequency\ of\ occurence\ or\ return\ period$
$A = watershed\ area\ in\ acres$
$Tc = rainfall\ intensity\ averaging\ time, equal\ to\ the\ time\ required\ for\ water\ to\ flow\ from\ the\ hydraulically\ most\ distant\ point\ int\ he\ watershed\ to\ the\ point\ of\ design$

A desk study was also undertaken to draw the watersheds and delineate the catchment area of Triq Sir Anthony Mamo and the Wied Għollieqa valley on a scale of 1:2500. A study of aerial photographs taken in the area was carried out to determine the different land use within the catchment area which may influence the flow and volume of water runoff. This information was also required to determine the average runoff coefficient of the catchment unless it is assumed that the catchment is homogenous. This applies only where there is only one principal land use in the catchment area and hence one runoff coefficient. A weighted average runoff coefficient (Ce) is used when there are multiple land uses.

A field survey was subsequently undertaken to confirm the findings from the desk study. Since the study was carried out in Summer 2023 due to restricted timeframes, the expert was not able to witness the effects of rainwater runoff directly on site.

2.1.2 Terrestrial Ecology

Since the proposed interventions are located at a considerable distance away from the Special Area of Conservation site at Wied Għollieqa (MT1000003), the terrestrial ecology study does not have a clearly defined Area of Influence around the Scheme site.

Instead, the ecologist considered the entire footprint of the Wied Għollieqa. The emphasis of such work shall be on the ecological dynamics of the site and how these are governed by the influx and retention of surface water run-off at the site.

A thorough literature review of readily available data and previous studies conducted in the area was considered. Following on from the desktop study, a broad-brush terrestrial survey within the valley was conducted. The Consultant shall record the vegetation assemblages and any faunal species encountered during the survey. Photographic evidence was collected during the field survey.

The report details the conservation status and ecological condition of the area and the state of health of its habitats, species and ecological features. All protected, endangered, rare, unique, endemic, high-quality, keystone, invasive/deleterious, or otherwise important species, habitats, ecological assemblages, and ecological conditions found in the area under study were studied.

2.2 Impact Assessment Criteria

The Consultant evaluated the potential impacts arising from the construction and operation of the proposed Scheme on the local terrestrial ecology. The potential impacts also provided a basis for comparison between the existing conditions and the new conditions established during the operation of the Scheme.

The following information have been provided for each of the identified impacts:

- Project phase (construction or operational phase)
- Policy importance
- Extent of effect (widespread or localised)
- Duration (temporary or permanent)
- Type (beneficial or adverse)
- Reversibility (reversible or irreversible)
- Sensitivity of receptors (high, moderate or low)
- Probability of occurrence (inevitable, likely, uncertain, unlikely or remote)
- Scope for mitigation or enhancement (very good, good or none)

Based on the above criteria, the Consultants assessed the significance level of each of the identified impacts. Different criteria were used for the different components of the study, as summarised in Table 1 to Table 9.

TABLE 1: DURATION OF IMPACT CRITERION DESCRIPTION

DURATION OF IMPACT

Permanent	Impact would still be detectable following decommissioning of project
Temporary	Impact would persist throughout the phase of project under consideration only

TABLE 2: EXTENT OF IMPACT CRITERION DESCRIPTION

EXTENT OF IMPACT

Widespread	Impact is expected to affect in the entire area of study and/or may extend beyond the boundaries of direct intervention into adjacent areas
Localised	Impact is expected to affect receptors in the immediate vicinity of its source

TABLE 3: CONSEQUENCES OF IMPACT CRITERION DESCRIPTION

CONSEQUENCES OF IMPACT

Direct	Changes that result from the cause-effect consequences of interactions between the environment and project activities
Indirect	Changes that result from cause-effect consequences of interactions between the environment and direct impacts
Cumulative	The cumulative consequences of ecological impact refer to the gradual and long-term effects that result from the combined impact of various ecological disturbances or stressors on an ecosystem over time.

TABLE 4: EFFECT OF IMPACT CRITERION DESCRIPTION

EFFECT OF IMPACT

Adverse	A negative effect on the sustainability of the resource under consideration, which are distinguishable from background fluctuations
Beneficial	A positive effect on the sustainability of the resource under consideration, which are distinguishable from background fluctuations

TABLE 5: REVERSIBILITY OF IMPACT CRITERION DESCRIPTION

REVERSIBILITY OF IMPACT	
Reversible	The state of the resource is expected to return to baseline state following cessation of the source of impact
Irreversible	The state of the resource is not expected to return to baseline state following cessation of the source of impact

TABLE 6: SENSITIVITY OF RESOURCES TO IMPACT CRITERION DESCRIPTION

SENSITIVITY AND RESILIENCE OF RESOURCES TO IMPACT	
High	The resource under consideration is highly susceptible to a detectable deviation from the background state and its general dynamics
Moderate	The resource under consideration is vulnerable but able to tolerate a degree of detectable deviation from the background state and its general dynamics
Low	The resource under consideration is highly tolerant to a detectable deviation from the background state and its general dynamics

TABLE 7: PROBABILITY OF IMPACT OCCURRING CRITERION DESCRIPTION

PROBABILITY OF IMPACT OCCURRING	
Inevitable	Impact will occur irrespective of any mitigation measures taken
Likely	Impact may occur despite the implementation of mitigation measures
Unlikely	Impact would only occur in cases of major mitigation failure
Remote	Impact would only occur in exceptional circumstances
Uncertain	Probability of impact cannot be predicted reliably due to missing information or unknown factors

TABLE 8: IMPACT SIGNIFICANCE CRITERION DESCRIPTION

IMPACT SIGNIFICANCE	
Significant	Will affect keystone and/or protected species and/or habitats
Non Significant	Will not affect any keystone and/or protected species and/or habitats

TABLE 9: RESIDUAL IMPACT SIGNIFICANCE CRITERION DESCRIPTION

RESIDUAL IMPACT SIGNIFICANCE	
Signficant	The effect on the existing state of the feature under consideration will lead to a noticeable and significant change in its resilience after application of mitigation measures (if any) and impact cessation
Non Significant	The effect on the existing state of the feature under consideration will lead to no significant change that will alter its resilience after application of mitigation measures (if any) and impact cessation

2.3 BASELINE STUDY

2.3.1 Hydrological aspects

Presently, the Industrial Estate & the residential area of San Gwann (known as Ta'Żwejt Area) including the area in the vicinity of the Life Science Park, form part of the same catchment area. All the stormwater runoff from these catchments flows through Triq Sir Anthony Mamo.

During rainfalls of moderate to high intensities, the existing stormwater infrastructure in this area was noted to be insufficient to collect and discharge the runoff at the outlet in Wied Għollieqa. This insufficiency results in flooding along stretches of this road during which the runoff travels across the surfaces of Triq Sir Anthony Mamo and Triq San Ġiljan to discharge slowly into Wied Għollieqa.

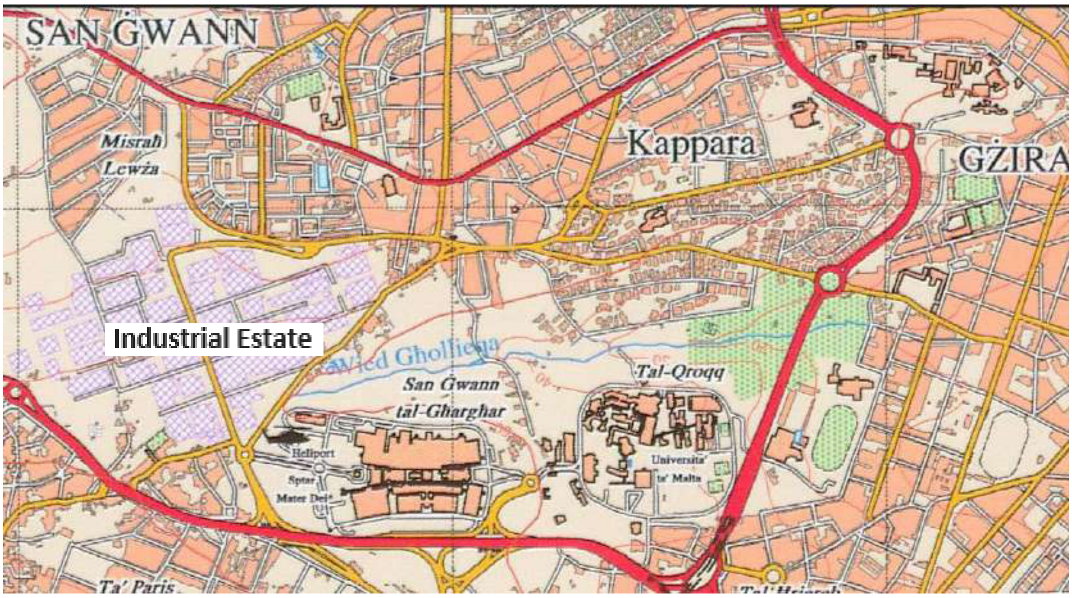


FIGURE 5: MAP SHOWING THE LOCATION OF MISRAH LEWZA, SAN GWANN INDUSTRIAL ESTATE AND WIED GHOLLEQA (FOR SCALE GRID SQUARES MEASURE 1000M BY 1000M

2.3.1.1 Description of Wied Għollieqa

Wied Għollieqa is a magnificent valley cut in Lower Globigerina Limestone and parcelled into terraced fields demonstrating a once intense agricultural activity. Unfortunately, agriculture has long been abandoned in the lower reaches of the valley and since that time has been degraded by several developments which have indented the original morphology and landscape of the valley (Figure 6).

The site has been designated as an area of Ecological Importance and Site of Scientific Importance (designated through Govt. Notice 869 of 2009 and 241 of 1997, respectively).

FIGURE 6: MAP OF WIED GĦOLLIEQA AND ITS ENVIRONS DESIGNATED AS AN AREA OF ECOLOGICAL IMPORTANCE AND SITE OF SCIENTIFIC IMPORTANCE (PLANNING AUTHORITY MAPSERVER).

The valley has its hydrological source at Ta' Żwejt and San Ġwann Industrial Estate at a maximum elevation of 98m. Presently it discharges runoff at an elevation of 12m at the Kappara Road Junction in Gżira. From this point it is led into the subsurface through a tunnel cut in the Gżira Subsurface and connects with the National Flood Relief tunnel network that discharges into Marsamxett Harbour at Ta' Xbiex.

The valley represents the only open space in a vast area which is extensively developed and paved, incorporating the villages of Gżira, San Ġwann, Kappara, tal-Qroqq and Mater Dei Hospital. Recent development at the University Car park at Tal-Qroqq and the Kappara junction has intruded the valley's general layout such that at one point it has been reduced to a mere constriction of open space. This constriction divides the valley into a Western very gently sloping segment which is parceled into fields with ongoing agricultural activities with no apparent real watercourse present. The Eastern segment is deeply incised and where a true gently meandering water course is developed at times flanked by a narrow flood plain particularly evident at its termination near the Kappara junction in Gżira.

Wied Għollieqa also encompasses abandoned agricultural terrain, still neatly terraced, now densely wooded with local trees and shrubs such as carob and olive as well as alien species. The eastern segment is also steeply terraced marking a one-time agricultural area, like the northern segment. Rock exposures are quite frequent in a corridor running parallel to the watercourse. Some of the most interesting features within the valley are shown in Figure 7 to Figure 10.

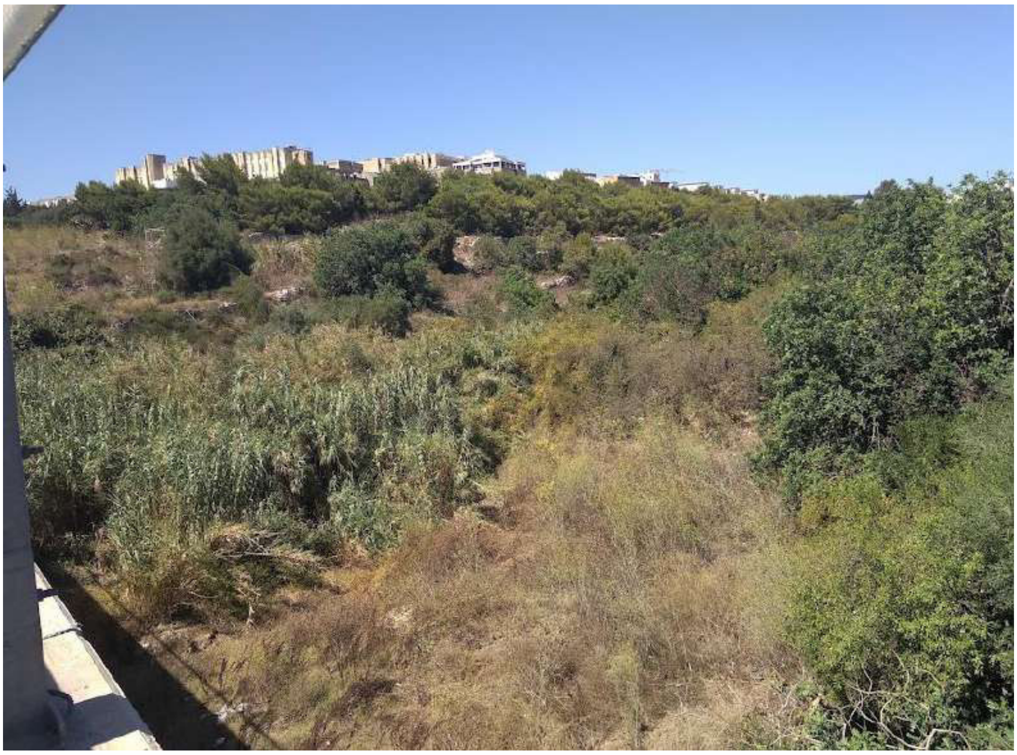


FIGURE 7: VIEW OF WIED GĦOLLIEQA FROM THE KAPPARA JUNCTION- UNIVERSITY HEIGHTS N THE BACKGROUND

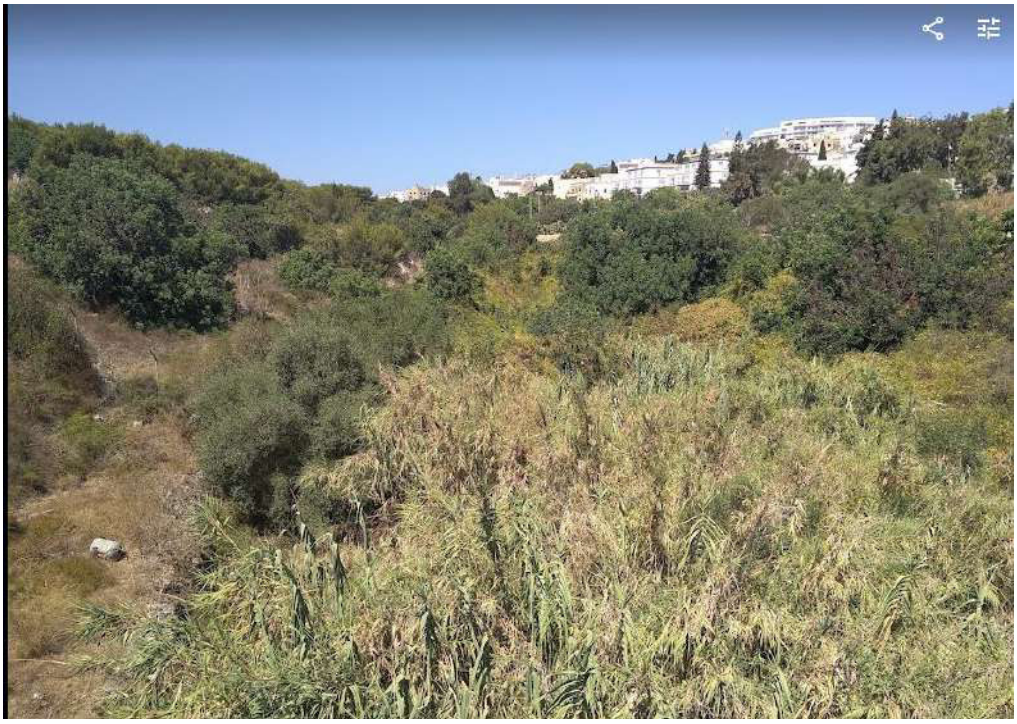


FIGURE 8: VIEW UPSTREAM OF THE WATERCOURSE AS SEEN FROM THE KAPPARA JUNCTION

FIGURE 9: TERRACED FIELDS SURROUNDED BY RUBBLE WALLS NEXT TO THE UNIVERSITY CAMPUS

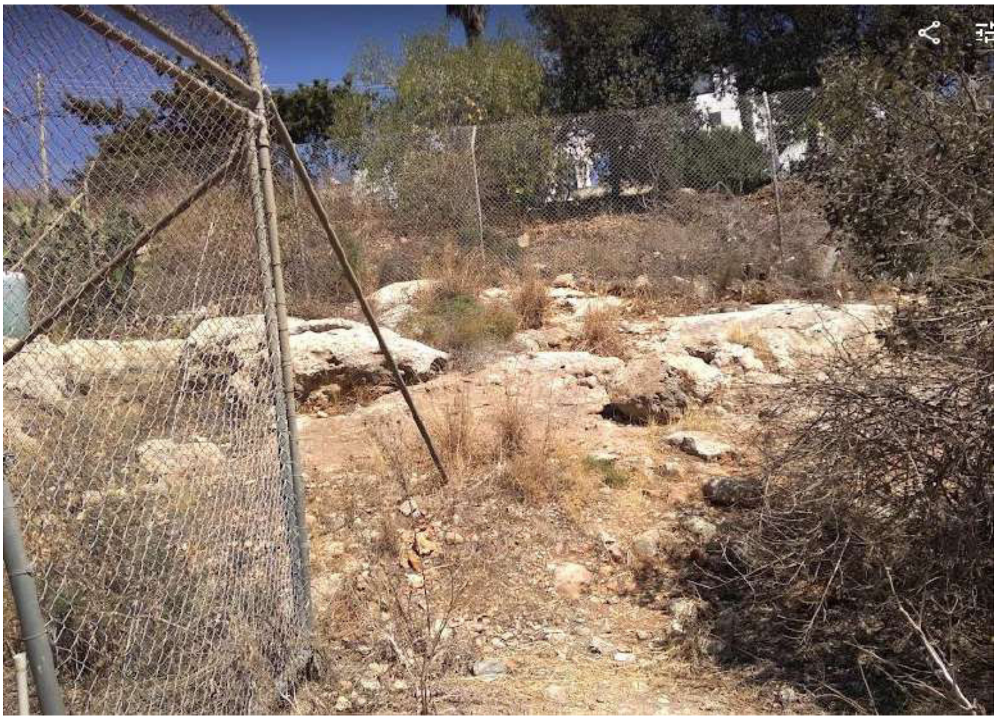


FIGURE 10: ROCK EXPOSURES ARE COMMON ON THE SLOPES OF THE VALLEY

2.3.1.2 Geology of the site

The only rock unit preserved in the Study Area is Lower Globigerina Limestone Member. Exposures of this rock unit are very frequent on the slopes bordering the central segment of the valley. Younger rock formations are not preserved. The Lower Coralline Limestone Formation is exposed in Wied Għomor some 500m to the Northwest of the valley Site. Past Ground investigation in connection with the Kappara Junction revealed that Quaternary continental deposits are also present in Wied Għollieqa. These consist primarily of red valley fill up to about 3m thick and small erosional potholes.

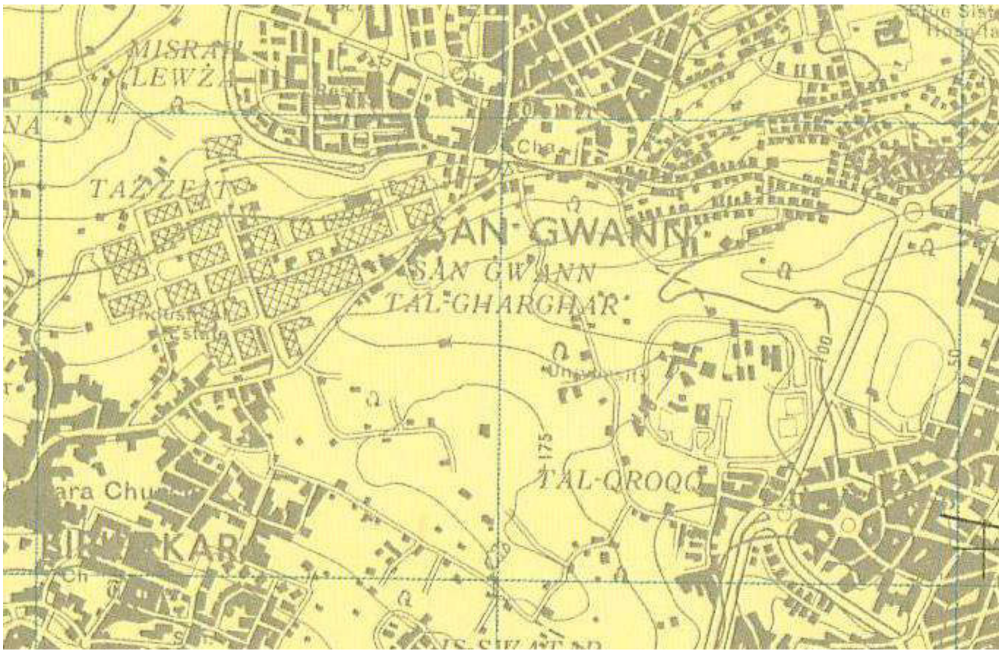


FIGURE 11: GEOLOGY OF WIED GĦOLLIEQA AND ITS ENVIRONS

The site lies in an intensely developed urban region. Most of the geomorphology has already been disturbed by past excavations. The site under study lies on the western segment of the catchment of the Wied. This slope is mostly, intensely developed with the exception of the watercourse which is partly interrupted by a Tennis Court.

This slope and watercourse are preserved down to Kappara Junction. From this point downstream, the valley is masked by intense development in Gżira. The natural watercourse originally was represented by Triq Turu Rizzu which conveyed run-off further downstream. Presently discharge of runoff is via a subsurface tunnel that connects to the National Flood Relief grid.

The main geomorphic units that can be seen within the catchment are therefore primarily represented by:

- Kappara – San Ġwann Ridge which is intensely developed and
- The northern slopes of Wied Għollieqa in which a belt of limestone pavement has been preserved. This is squeezed between the watercourse proper and the intense development which characterize the rest of the slope.
- The watercourse of Wied Għollieqa which mostly lies out of the Area of Influence. The part within the AoI is represented by terraced fields, immediately downstream of the bridge crossing the valley. From this point the natural watercourse originally was replaced by Triq Turu Rizzu, now replaced by a tunnel which conveys run-off further downstream in the Gzira subsurface.
- Soils: The least disturbed area is the area straddling the bridge. Boreholes drilled within this area tested Lower Globigerina Limestone. Lower Globigerina Limestone outcrops at the surface. Similarly, the excavation for

the reservoir showed rock (Lower Globigerina Limestone) outcropping at the surface.

2.3.1.3 Climate description

Malta is situated in the Mediterranean basin between Sicily and Tunisian peninsula. This position offering a special weather, Sicily can act against strong low-level northerly winds and North African low-pressure system has the potential to produce strong winds.

This island has a Subtropical-Mediterranean climate including mild winter and hot summer. The seasonal features can be traced from the motion and development of the pressure systems over Atlantic, Eurasia and Africa.

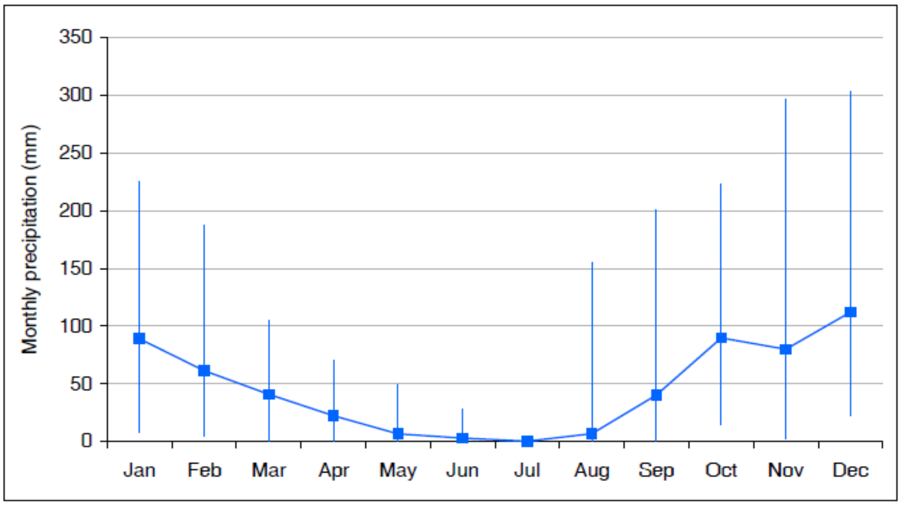
Advances of continental tropical air into the central Mediterranean after a cold spell can give rise to active warm fronts, sometimes producing very active cumulonimbus clouds, copious rainfall and thunderstorm.

In order to determine the impact of storms events on the Industrial Estate and Wied Għollieqa, literature studies on runoff water resulting from storms or flash floods was considered. Some precipitation statistics are present in Table 10.

TABLE 10: SUMMARY OF STATISTICS FOR PRECIPITATION (GALDIES, 2011). NOTE AVERAGE REFERS TO AVERAGE ANNUAL RAINFALL IN MM

Count	30 years (1961-1990)
Average	553.12
Standard deviation	156.99
Coefficient of variation (%)	28.38
Minimum	274.22
Maximum	874.10
Range	599.88
Standard skewness	-0.018

The information presented in Table 10 is based on the long-term averages of a number of climatic parameters that have been continuously observed at Luqa airport by the Malta Airport Metoffice during the period 1961-1990.

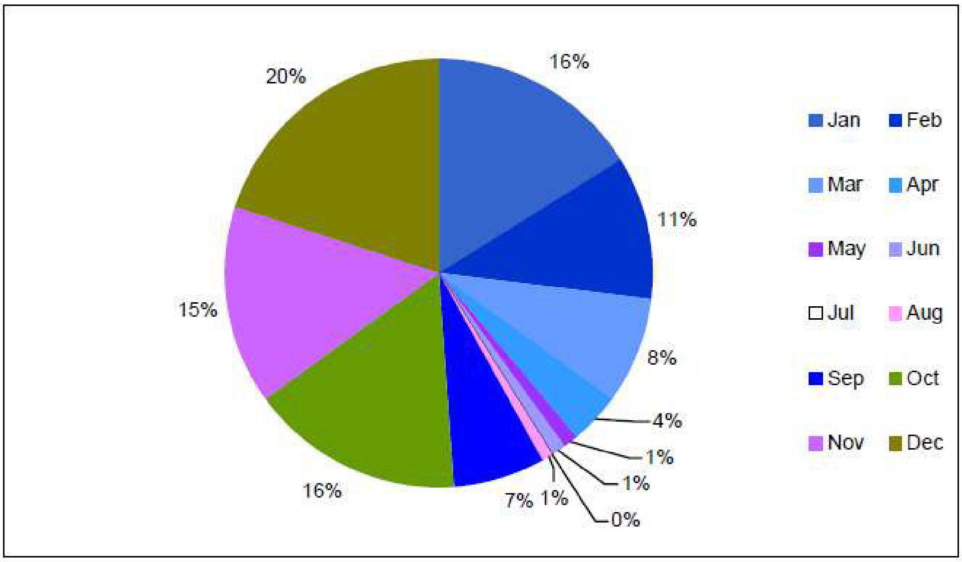


Data collected by the Malta Airport MetOffice

FIGURE 12: MONTHLY MEAN PRECIPITATION AND VARIABILITY BASED ON A 30 YEAR CLIMATE PERIOD (1961 TO 1990)

Rainfall varies widely and in unpredictable manner as shown in Figure 12 which shows the 30-year average monthly rainfall and the variability in each month during the same 30-year period. The major part of annual precipitation in Malta occurs between October – February (62%), December being the rainiest.

The monthly distribution of the total annual rainfall is shown in Figure 13.



Data collected by the Malta Airport MetOffice

FIGURE 13: PIE CHART SHOWING THE MONTHLY DISTRIBUTION OF THE ANNUAL RAINFALL

For the purpose of this study, we tentatively consider that:

- a “low precipitation” is equivalent to 0-40 mm/day,
- an average precipitation equivalent to 40-80 mm/day and
- a storm- flash flood precipitation when the rate is more than 80mm/day.

Historical data which was purchased from the Meteorological Office Luqa permitted the production of seasonal chart of rain events and storm return periods.

2.3.1.4 Water balance equation

The water balance of a catchment area is defined by an inflow and outflow compares:

$$P + S = R + E + (S \pm \Delta S)$$

P : Precipitation (liquid and solid) [mm],

S : Water storage (accumulation) of last storm period (inflow water, ground humidity) [mm],

R : Runoff and underground flows [mm],

E : evaporation (evapotranspiration) [mm],

S + ΔS : resources collected at the end of the storm period [mm].

The runoff coefficients estimation of the catchment of Wied Għollieqa is tied to scientific analysis. The average Maltese Island run-off has been based on local scientific research on the local water cycle and similar Mediterranean karstic regions (Gutierrez, 1996; Contreras & al., 2011; Bailly-Comte, 2008). Runoff coefficient are between 0 (maximum infiltration) to 1 (maximum runoff) depending on ground surface and subsurface conditions, such as ground moisture and different ground surfaces present in the catchment area (presence of fractures karstic conduits fault etc).

Values for Maltese runoff coefficient for the Upper Coralline Limestone are found in Gutierrez 1996. While average runoff coefficient for the mean sea level aquifer is given as 10% in the 2nd Water Catchment Management Plan for the Malta Water Catchment District 2015 – 2021. For an accurate measurement of runoff specific runoff coefficients are required depending on land use.

2.3.1.5 Precipitation

The storm return period also known as a recurrence interval is an estimate of the interval of time between storm events of a certain intensity or size. It is a statistical measurement denoting the average recurrence interval over an extended period of time. In this study it shall be used to design appropriate drainage structures to withstand an event with a certain return period.

The main task in order to qualify and identify the different rainfall intensities was to process daily rainfall data acquired from Meteorological Office MIA, Luqa for 42 years. The design return period has been calculated by applying the Poisson distribution and results are presented for each rainfall intensity.

The only available information with reference to rainfall intensity – duration – frequency for the Maltese Islands was found in the 1992 report of “Sewerage Master Plan for Malta and Gozo”, Final Document, Volume 1: Plan, based on a former study by Kevin Gatt: “Precipitation Quantities in the Local Environment (1991)”. The rainfall data statistically analyzed by Gatt was the Luqa five-minute records of the period for 1949

– 1988. The 1992 report used the Gatt results, but corrected them using a procedure applied by the 1972 ATIGA study: “Waste Disposal and Water Supply Project, Vol. II, Part I-IV”. (Tahal Group, 2007).

Table 11 presents the intensity – duration – frequency relationships taken from the above mentioned 1992 report for three selected return periods: 5-years, 10-years, and 20-years. The data from Table 11 has been plotted and shown in Figure 14.

In this table the return period is related to the rainfall duration in minutes. On the other hand, in this study the data available was daily rainfall for 40 years. The return period calculated has been for:

- 40m to 60mm;
- 60mm to 80mm and
- Rainfall greater than 80mm.

TABLE 11: METEOROLOGICAL OFFICE LUQA STATION: RAINFALL INTENSITY-DURATION-RETURN PERIOD (FREQUENCY) RELATIONSHIPS (1949-1988) FROM [TAHAL GROUP, 2007]

Duration (minutes)	Rainfall Depth (mm) having Return Period of:		
	5-Years*	10-Years**	20-Years***
5	12.6	12.8	13.2
10	20.1	21.2	22.8
15	25.3	27.9	30.2
30	34.9	41.2	45.5
60	44.9	55.8	62.5
120	55.0	70.8	79.8
180	61.1	79.6	89.9
240	65.6	86.0	97.1
300	69.1	91.0	102.7
360	72.1	95.1	107.3
480	77.0	101.9	114.8
1440	97.7	130.2	145.4

*20% frequency; **10% frequency; ***5% frequency

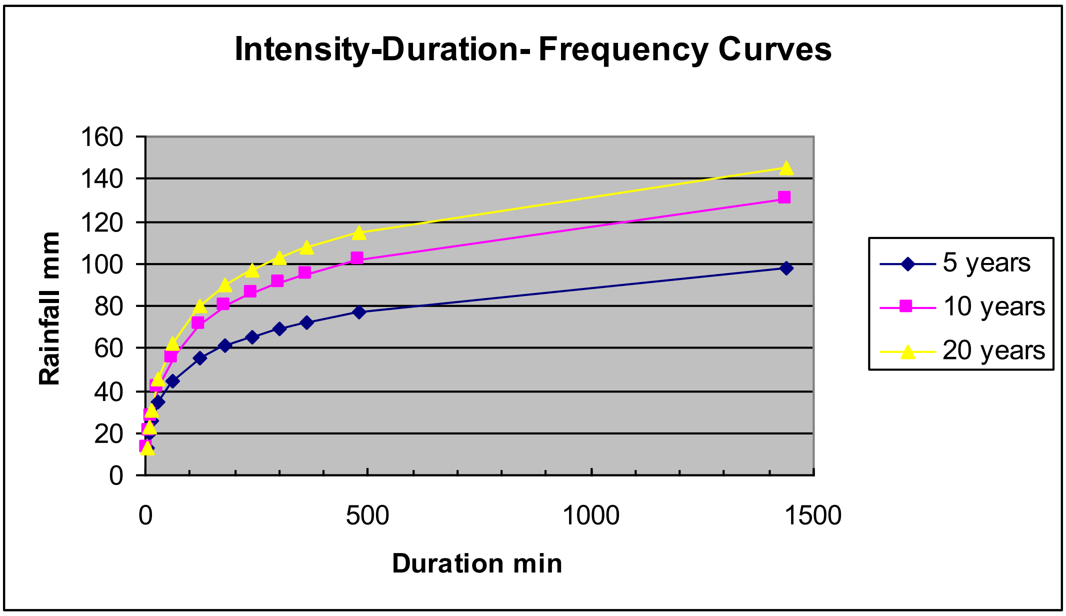


FIGURE 14: PLOT OF INTENSITY- DURATION FREQUENCY DATA SHOWN IN TABLE 6, ABOVE.

In order to identify the rainfall intensity events which needed to be selected for statistical analysis, the daily rainfall data acquired from the Meteorological Office, MIA, Luqa has been grouped and plotted in the following charts each representing a 10-year (daily) rainfall interval for ease of illustration:

- Daily rainfall Data collected by the met Office Luqa for the Luqa pluviometric station, extending over a 40-year period plotted in 10-year intervals.

This data was processed to determine the storm event characteristics by statistical methods outlined below.

It is important to note that data provided is recorded in mm/day, but the rainfall may not be continuous and a record of 50mm on one day could represent a precipitation that lasts for 1 hour or a precipitation that occurred in a time interval of 10 hours, for example. This study is based on rainfall data recorded in mm/day.

According to Bowen-Jones et al, 1960, the definition of 'storm rainfall' is necessarily subjective. Observation would suggest that a continuous fall amounting to 2" of rainfall leads to significant run-off and physical damage, and such conditions are likely to occur on any day with 3" or more of rain. Accepting this definition there is a storm rainfall event every day that 75mm of rainfall is recorded (80mm in this study).

The determination of a storm event is based on this definition and has been applied to determine the runoff created by a rainfall with a minimum intensity of 80 mm/day. Heavy rainfall event represents an intensity ranging from 60 to 80 mm/ day.

This definition of rain intensity suggests a rainfall event producing a significant runoff within the catchment area. A significant rain event represents a rainfall intensity ranging from 40 to 60 mm/day.

The charts shown in Figure 15 to Figure 18, show the daily precipitation between the 1/01/1980 to the 31/12/2022 purchased from the MetOffice MIA Luqa. On the charts each line graph represents the daily precipitation for a year.

Although the data appears cluttered, the scope of the charts is to identify the number of days with daily rainfalls peaks which are over 40mm, over 60mm and over 80mm. These appear as (few) peaks which stand out in the charts. The peaks with a daily rainfall over 80mm (Storm rainfall event) are even fewer. The peaks have been counted to calculate the storm return period by statistical analysis methods.

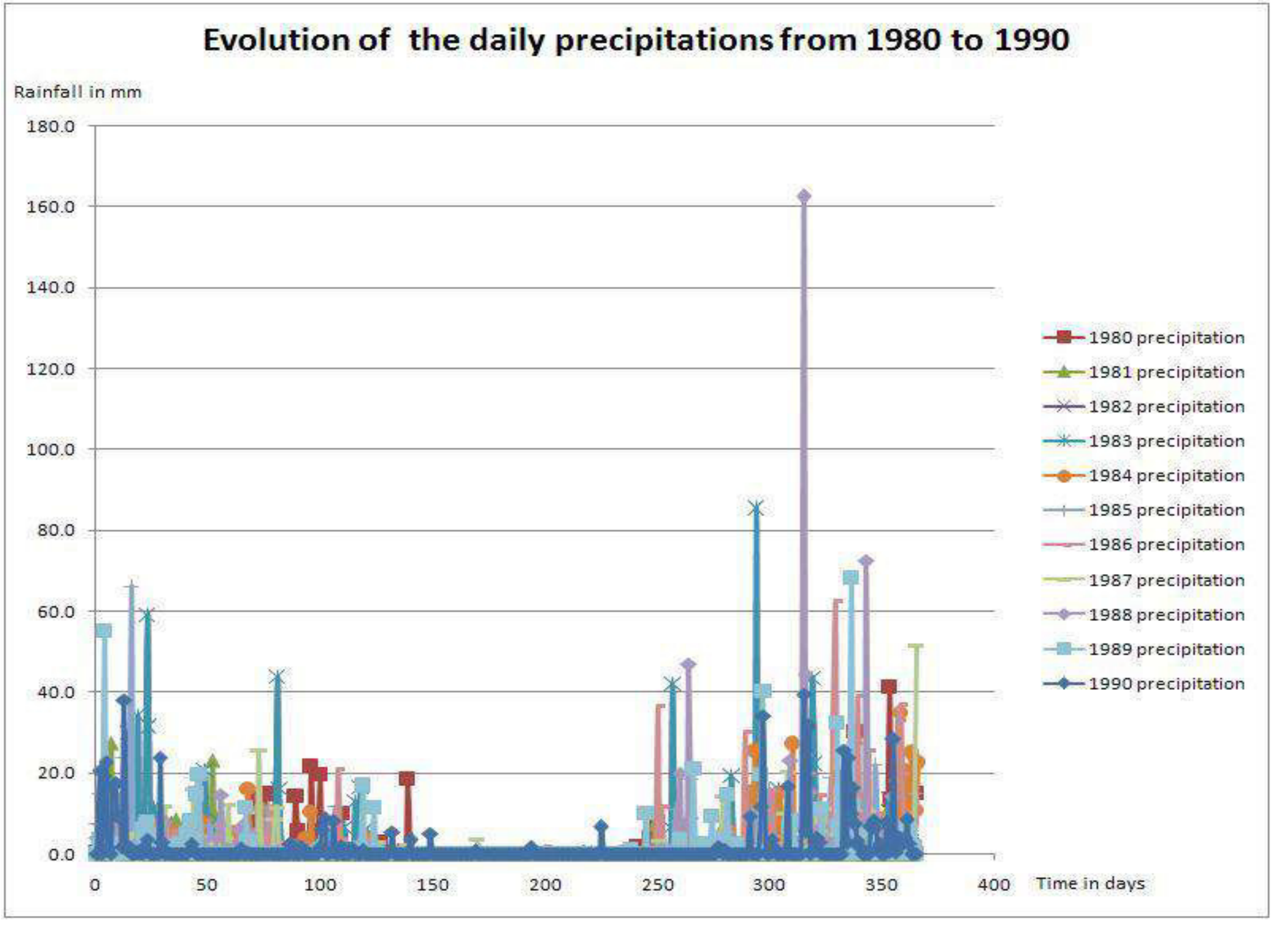


FIGURE 15: CHART REPRESENTING DAILY PRECIPITATION IN MM BETWEEN THE 1/01/1980 TO THE 31/12/1990, DATA FROM MET OFFICE, LUQA STATION.

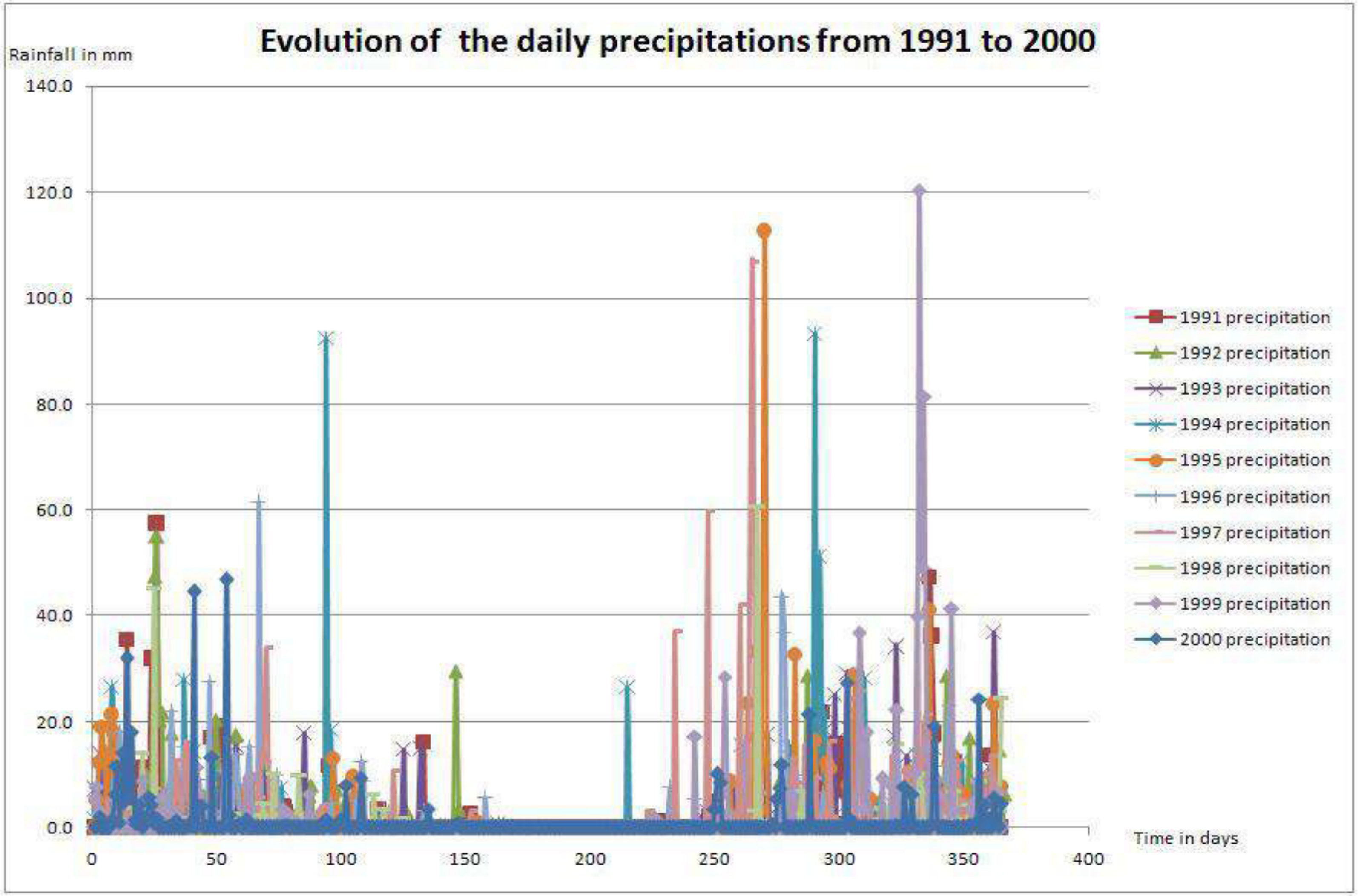


FIGURE 16: CHART REPRESENTING DAILY PRECIPITATION IN MM BETWEEN THE 1/01/1991 TO THE 31/12/2000, DATA FROM MET OFFICE

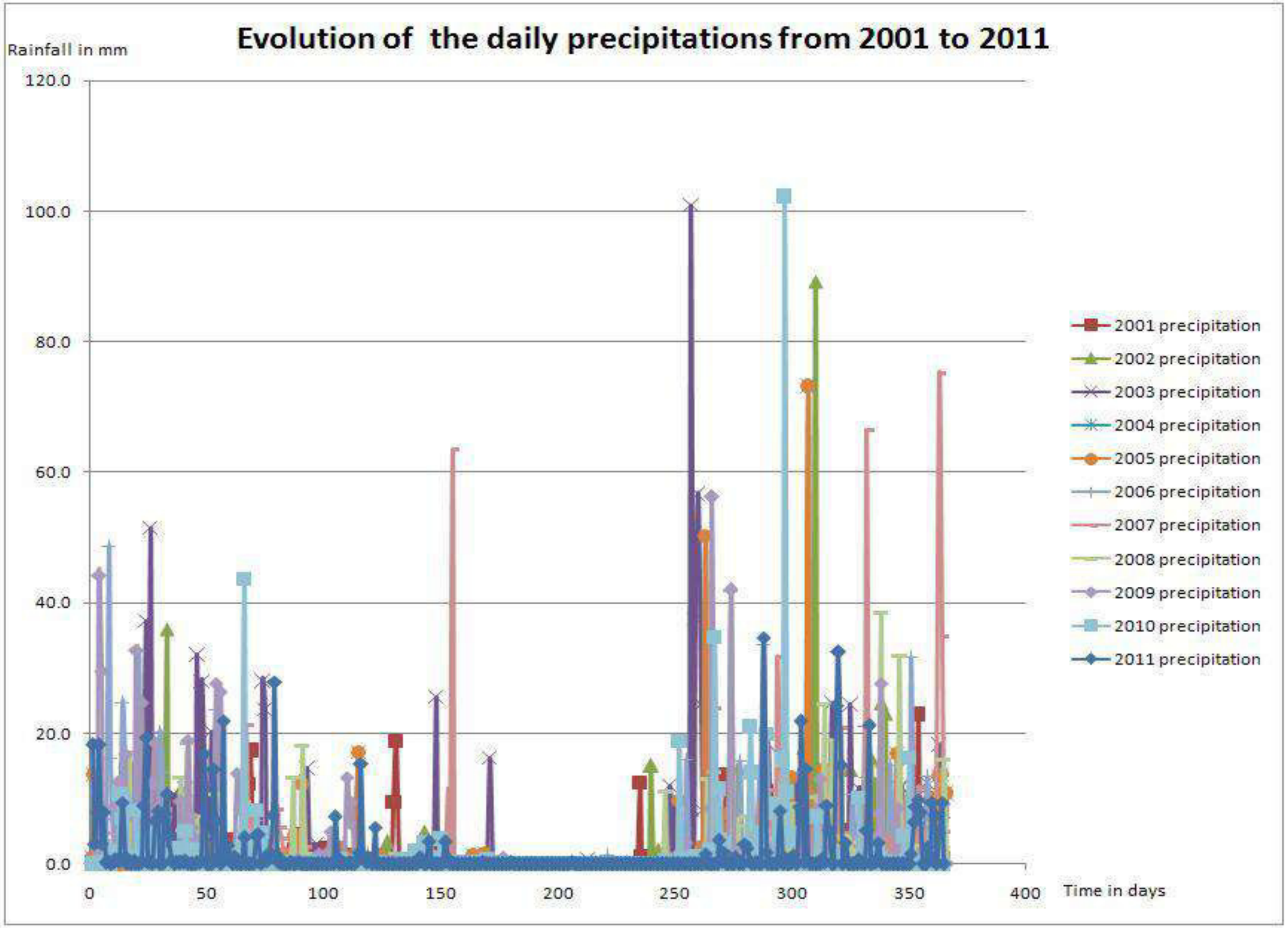


FIGURE 17: CHART REPRESENTING DAILY PRECIPITATION IN MM BETWEEN THE 1/01/2001 TO THE 31/12/2011, DATA FROM MET OFFICE

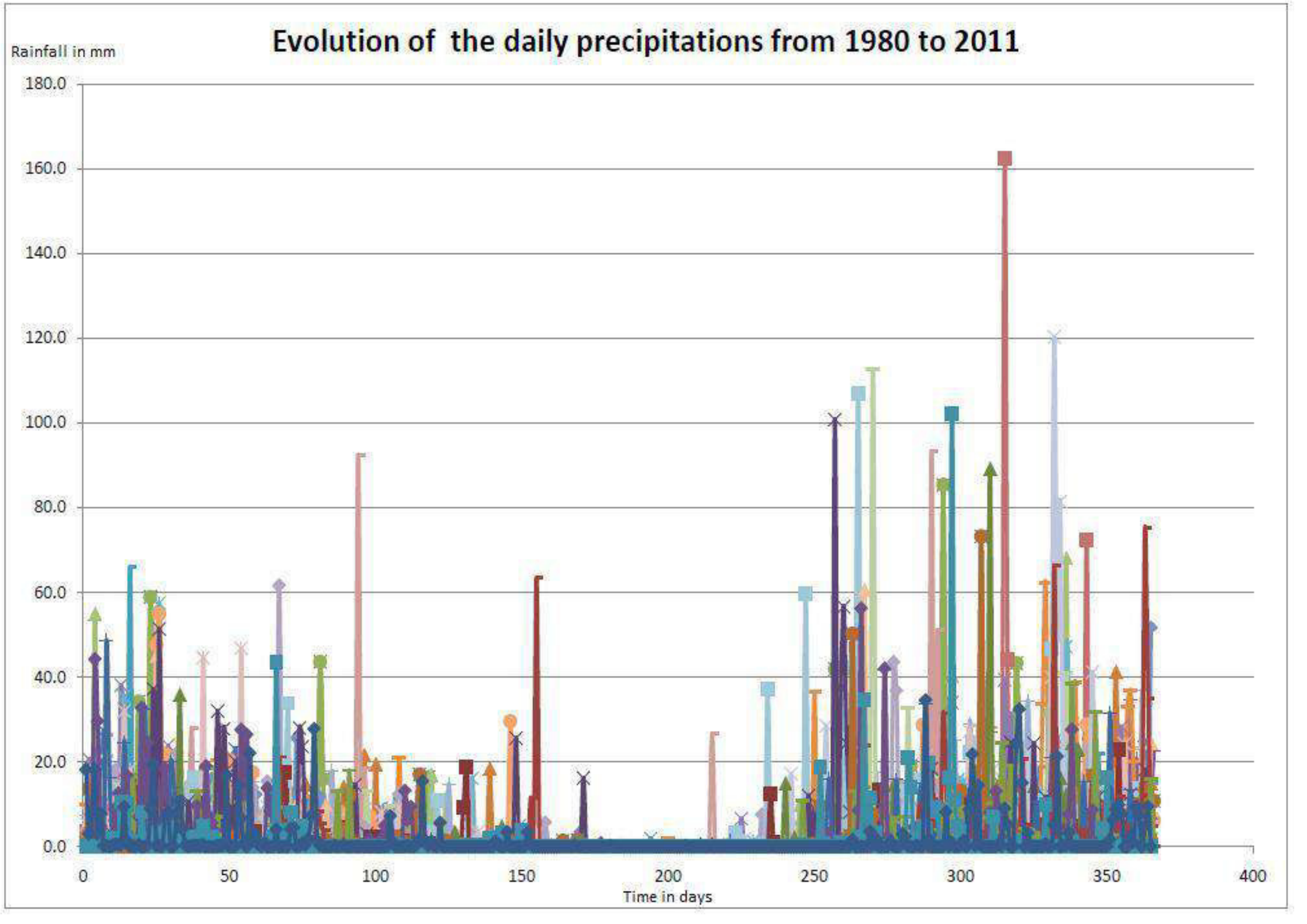


FIGURE 18: CHART REPRESENTING DAILY PRECIPITATION IN MM BETWEEN THE 1/01/1980 TO THE 31/12/2011, DATA FROM MET OFFICE

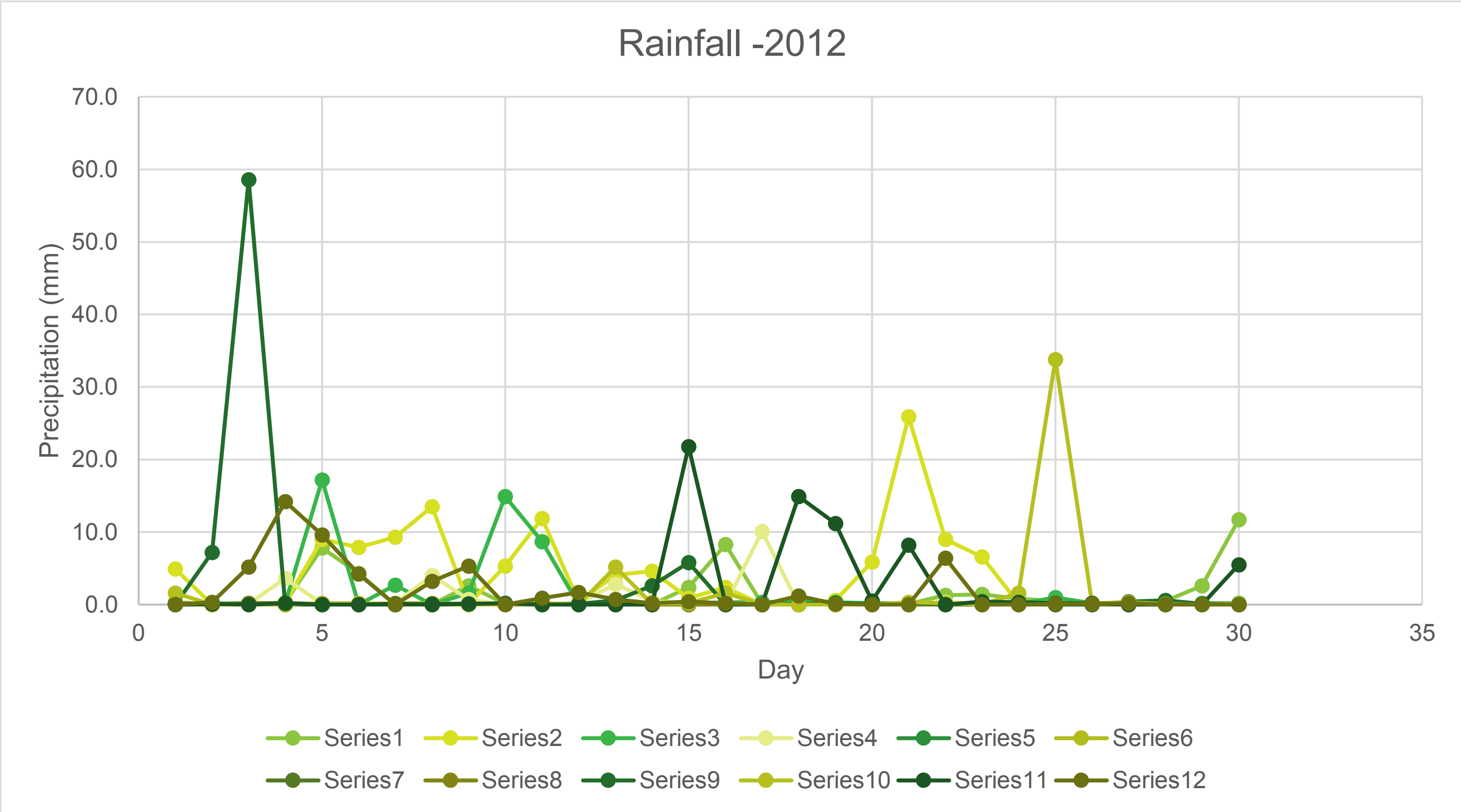


FIGURE 19: RAINFALL DATA IN 2012 (SERIES = MONTHS)

The peaks of these charts mark the three main rainfall intensities defined as follows:

- Storm events – Rainfall: Over 80mm/day (Adapted from Bowen-Jones 1961)
- Heavy rainfall events– Rainfall ranging from 60mm to 80mm/day
- Significant rainfall event – Rainfall ranging from 40mm to 60mm/day

The return period also known as a recurrence interval is an estimate of the interval of time between storm events. It is a statistical measurement denoting the average recurrence interval over an extended period of time.

The following analysis assumes that the probability of the event occurring does not vary over time and is independent of past events. The return period is estimated by the following equation:

$$T = \frac{n}{m}$$

Where:

- n is the number of years on record (42years)
- m the number of recorded occurrences of the event being considered.

The statistical frequency is deduced from the return period:

$$F = \frac{1}{T} = \frac{m}{n}$$

The low event occurrences limited the use of this simple equation. In a given period of *n* years (our calculation is based on a one-year period), the probability of a given number *m* of events of a given return interval *T* is given by the binomial distribution as follows. In the limit of long periods (as *n* becomes large), this converges to the Poisson distribution.

$$P = \binom{n}{r} \times p^r \times (1-p)^{n-r}$$

In our calculations n=r=1 and therefore P=p

The results of the calculation of the storm return period and probability of occurrence of: storm events, heavy rain events and significant rain events are summarised in the table below.

Each table presents the frequency, the recurrence interval and the probable intensity for one year. With reference to these tables, it is recalled that:

- m: Number of recorded occurrences of the event was measured by counting the days with rainfall peaks, as follows:
  - Storm periods : No of days with rainfall >80mm

- Heavy rainfall: No of days with rainfall, n, the range 60mm - 80mm
- Significant rainfall: No of days with rainfall, n, the range 40mm to 60mm

N = 42 years: is the number of years for which data has been acquired from the Metoffice, MIA, Luqa

TABLE 12: OCCURRENCE PROBABILITY AND TIME RETURN PERIOD DETERMINATION OF STORM EVENTS BETWEEN 1980 AND 2011

TABLE OF STORM RETURN PERIOD

Number of recorded occurrences of the event	m=	13
Number of years on record	N =	42
Occurrence probability of the event in the n years period	r =	1
Numbers of successive years considered	n =	1
Event probability (events/year)	*p* =	0.309
Event Frequency	F =	0.309
Time return period / recurrence interval (years)	*T* =	3.24
Probability that such an event occurs exactly r times in n successive years	**P =**	**0.309**

TABLE 13: OCCURRENCE PROBABILITY AND TIME RETURN PERIOD DETERMINATION FOR HEAVY RAINFALL EVENTS BETWEEN 1980 AND 2011

TABLE OF HEAVY RAINFALL RETURN PERIOD

Number of recorded occurrences of the event	m =	13
Number of years on record	N =	42
Occurrence probability of the event in the n years period	r =	1
Numbers of consecutive years considered	n =	1
Event probability	*p* =	0.310

TABLE OF HEAVY RAINFALL RETURN PERIOD

Event Frequency	F =	0.31 0
Time return period / recurrence interval (years)	*T =*	3.23
Probability that such an event occurs exactly r times in n successive years	**P =**	**0.31 0**

TABLE 14: OCCURRENCE PROBABILITY AND TIME RETURN PERIOD DETERMINATION OF SIGNIFICANT RAINFALL EVENTS BETWEEN 1980 AND 2011

TABLE OF SIGNIFICANT RAINFALL - RETURN PERIOD

Number of recorded occurrences of the event	m =	45
Number of years on record	N =	42
Occurrence probability of the event in the n years period	r =	1
Numbers of consecutive years considered	n =	1
Event probability= (m/N)	*p =*	1.071
Event Frequency	F =	1.071
Time return period / recurrence interval (years) =(1/F)	*T =*	0.93 3
Probability that such an event occurs exactly r times in n successive years	**P =**	**1.07 1**

Table 15 represents a summary of rainfall statistics frequency of occurrence of each event

TABLE 15: FREQUENCY, TIME RETURN PERIOD AND RECURRENCE PROBABILITY FOR EACH RAINFALL INTENSITY

	RAINFALL INTENSITY	FREQUENCY	TIME RETURN PERIOD (YEARS)	FREQUENCY OF EVENT OCCURRING IN:		
				2 YEARS	5 YEARS	10 YEARS
40 mm	Significant Rainfall	1.078	0.933	2.14	5.35	10.7
60 mm	Heavy rainfall	0.310	3.23	0.62	1.50	3.10
80 mm -	Storm	0.309	3.24	0.618	1.545	3.09

Table 15 shows that a significant intensity (with a precipitation between 40 to 60mm/day) has a frequency which is greater than 1 as this rainfall intensity event happens every 9 to 10 months (basing on our 42 -year data acquired from the Metoffice, MIA, Luqa).

The percentage occurrence probability is about 108% each year that is 1.08 times per year. The probability to observe this intensity only once in two years is 0.46.

With regards to heavy rainfall (precipitation between 60 to 80mm/day) the storm return period of 3.2 years has to be interpreted as a statistical+ frequency of one time every 3.2 years (Three years and 1 or 2 months). It does not mean that it is occurring every three- year interval, but there is 32% chance that this event happens every year.

The same interpretation is given concerning the storm rainfall occurrence probability. With a time return period of 3.24, one event occurs statistically every two years and seven months, which represent a 38% frequency each year.

2.3.1.6 Runoff

The path taken by runoff within the water catchment area is marked in blue in Figure 20 and Figure 21. The valley is also subdivided into various zones as indicated. The San Ġwann Industrial Estate is over 90% developed and built up. A true water course is lacking on the upstream section suggesting that run-off is scarce and Wied Għollieqa is in fact a dry valley. In fact, the valley is partitioned into land parcels bounded by rubble walls with no evident watercourse. A true watercourse is only developed further downstream close to the discharge point.

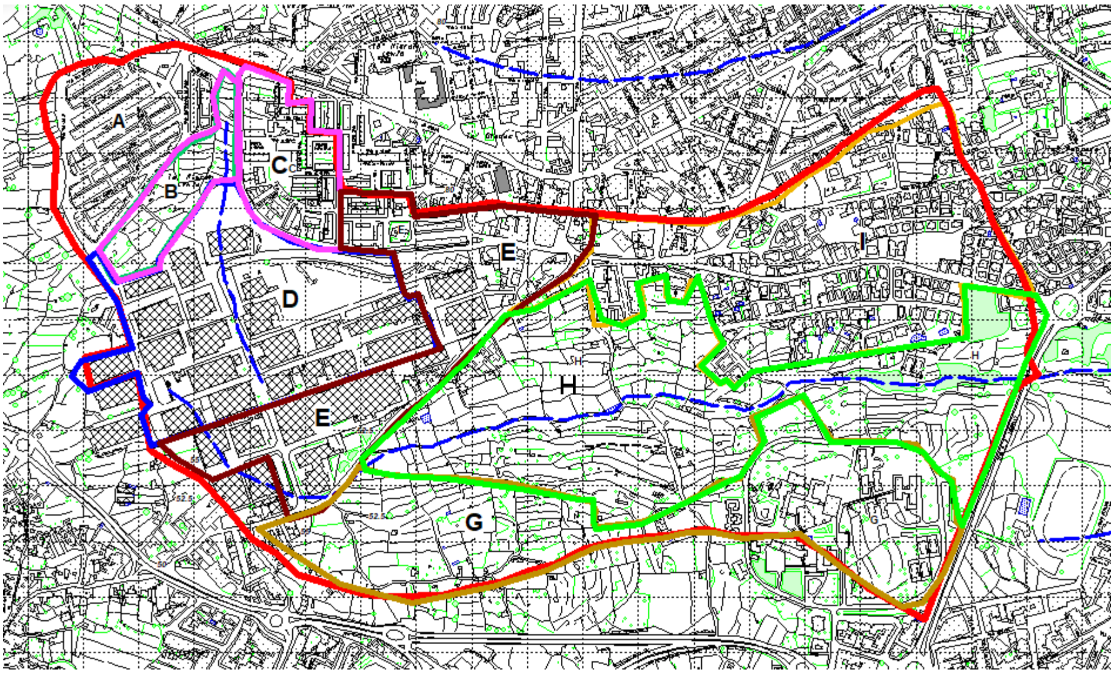


Figure 20: Hydrology of the water catchment area

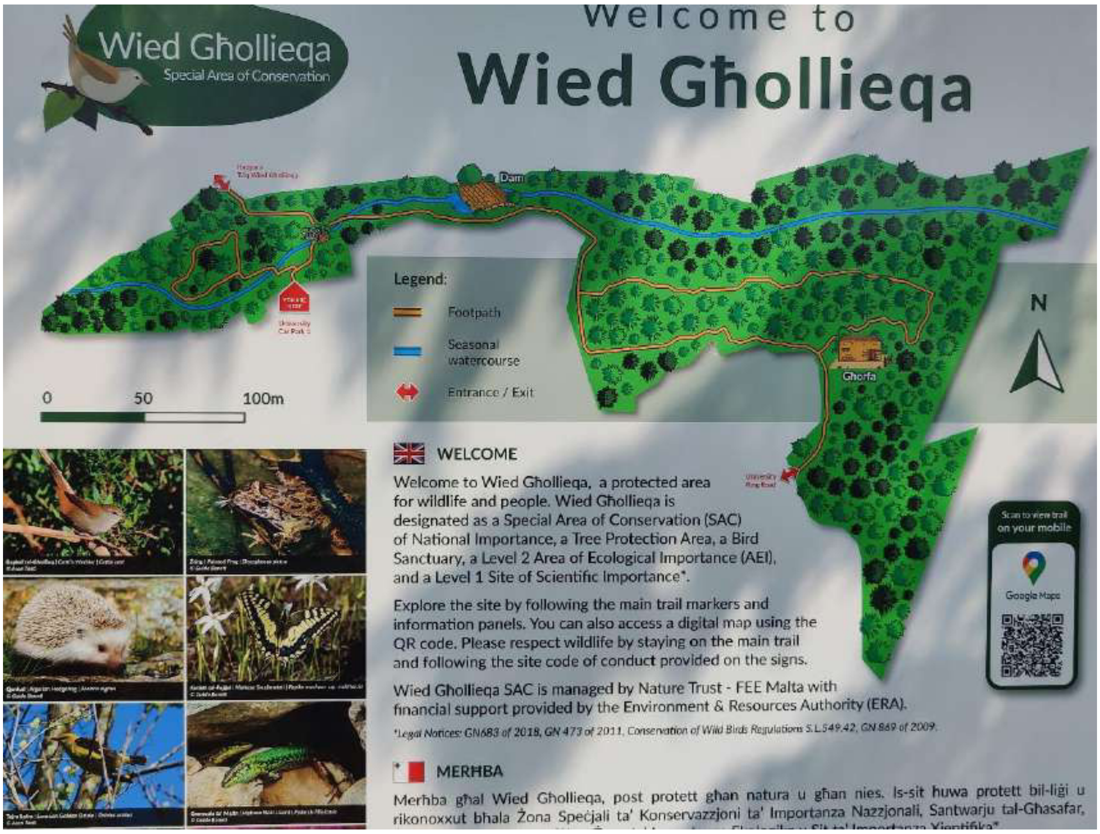


FIGURE 21: SITE NOTICE SHOWING SEASONAL WATER COURSE AND FOOTPATHS AT WIED GĦOLLIEQA

The Runoff volume estimates have been calculated using the Rational Method. The method involves a mathematical equation used for determining peak discharges from small drainage areas. This method is traditionally used to size storm sewers, channels, and other stormwater structures which handle runoff from drainage areas less than $50km^2$.

The rational formula for the estimation of peak run-off is:

$$Q = C.Im.A$$

- Q is the peak rate of runoff in cubic feet per second.
- C is the runoff coefficient representing a relationship between rainfall and runoff.
- Im is the average intensity of rainfall for the time of concentration (Tc) for a selected design storm in inches/hour.
- A is the drainage area in acres.

The limitations of the Rational Method are as follows:

- The drainage area should not be larger than 200 acres.

- The peak flow is assumed to occur when the entire watershed is contributing runoff.
- The rainfall intensity is assumed to be uniform over a time duration equal to or greater than the time of concentration, Tc.
- The peak flow recurrence interval is assumed to be equal to the rainfall intensity recurrence interval. In other words, the 10-year rainfall intensity is assumed to produce the 10-year flood.

The catchment area of the proposed flood relief shaft was determined using Mapinfo Software. The area of this catchment is 31.21 hectares which correspond to 77.21 acres.

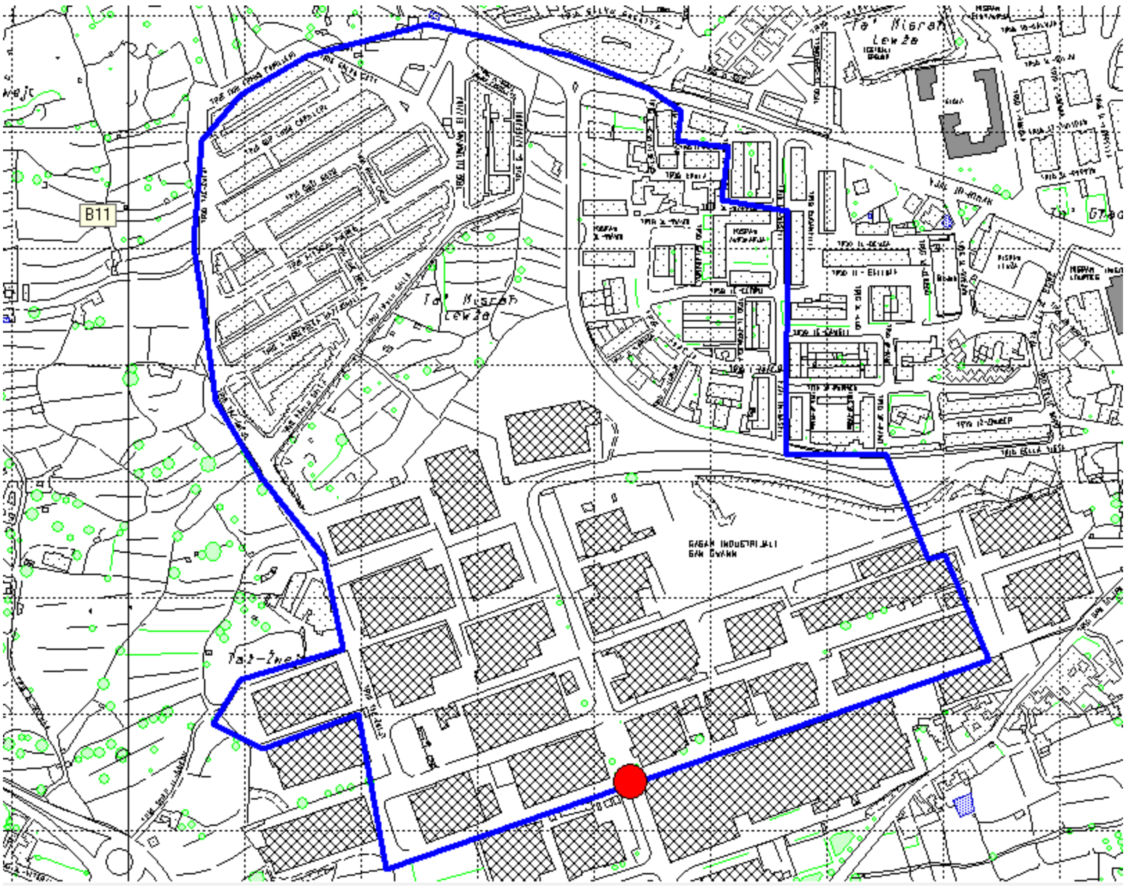


FIGURE 22: CATCHMENT OF THE PROPOSED FLOOD RELIEF SHAFT. FOR SCALE EACH GRID SQUARE IS 100M BY 100M

The major factors affecting the rational method runoff coefficient value for a watershed are the land use, the soil type and the slope of the watershed. The physical interpretation of the runoff coefficient for a watershed is the fraction of rainfall on that watershed that becomes storm water runoff. Thus, the runoff coefficient must have a value between zero and one.

1. Land Use: Surfaces that are relatively impervious like streets and parking lots have runoff coefficients approaching one. Surfaces with vegetation to

intercept surface runoff and those that allow infiltration of rainfall have lower runoff coefficients.

2. Slope: All other things being equal, a watershed with a greater slope will have more storm water runoff and thus a higher runoff coefficient than a watershed with a lower slope.
3. Soil Type: Soils that have a high clay content don't allow very much infiltration and thus have relatively high runoff coefficients, while soils with high sand content have higher infiltration rates and low runoff coefficients. The U.S. Soil Conservation Service (SCS) has four soil group identifications that provide information helpful in determining watershed runoff coefficients. The four soil groups are identified as A, B, C, and D. Classification of a given soil into one of these SCS groups can be on the basis of a description of the soil characteristics or on the basis of a measured minimum infiltration rate for the soil.
    - Group A: Deep sand; deep loess; aggregated soils
    - Group B: Shallow loess; sandy loam
    - Group C: Clay loams; shallow sandy loam; soils low in organic content; soils usually high in clay
    - Group D: Soils that swell significantly when wet; heavy plastic clays; certain saline soils

The soils found in the agriculture tenements and abandoned land, found within the catchment of Wied Għollieqa have a Group C Soil Type.

TABLE 16: SOIL GROUPS AND RUNOFF COEFFICIENTS[1]

	Soil Group C			Soil Group D		
Slope :	< 2%	2-6%	> 6%	< 2%	2-6%	> 6%
Forest	0.12	0.16	0.20	0.15	0.20	0.25
Meadow	0.26	0.35	0.44	0.30	0.40	0.50
Pasture	0.30	0.42	0.52	0.37	0.50	0.62
Farmland	0.20	0.25	0.34	0.24	0.29	0.41
Res. 1 acre	0.28	0.32	0.40	0.31	0.35	0.46
Res. 1/2 acre	0.31	0.35	0.42	0.34	0.38	0.46
Res. 1/3 acre	0.33	0.38	0.45	0.36	0.40	0.50
Res. 1/4 acre	0.36	0.40	0.47	0.38	0.42	0.52
Res. 1/8 acre	0.38	0.42	0.49	0.41	0.45	0.54
Industrial	0.86	0.86	0.87	0.86	0.86	0.88
Commercial	0.89	0.89	0.90	0.89	0.89	0.90
Streets: ROW	0.84	0.85	0.89	0.89	0.91	0.95
Parking	0.95	0.96	0.97	0.95	0.96	0.97
Disturbed Area	0.68	0.70	0.72	0.69	0.72	0.75

[1] https://www.brighthubengineering.com/hydraulics-civil-engineering/93173-runoff-coefficients-for-use-in-rational-method-calculations/

TABLE 17: SUMMARY TABLE OF RUNOFF COEFFICIENT FOR THE CATCHMENT SUBDIVISIONS OF WIED GĦOLLIEQA

TERRAIN TYPE	AREA/S (REFER TO FIGURE 20)	GRADIENT %	RUNOFF COEFFICIENT	AREA SQ M
Woody terrain	H	16	0.34	94,900
Cultivated terrain	H	7.5	0.34	156,300
Cultivated terrain	B	6	0.34	31,590
Residential	A	7	0.85	68,900
Residential	C	5	0.8	45,400
Residential	I	7	0.85	212,100
Mixed use	E	12	0.80	138,100
Mixed use	G	5	0.75	200,400
Industrial Estate	A, B and D	6	0.90	310,500
Wied Għollieqa	Total	-	-	1,167,000

A map showing the catchment portioned according to land use is shown in Figure 23.

Consequently, the catchment area for the proposed development has an area of 312,100m^2. This water catchment area includes the major part of the San Gwann Industrial Estate and the Ta' Żwejt Housing Estate.

The Wied Għollieqa catchment subsequently discharges at the Kappara Junction in the Gżira area, encompassing a footprint of 1,167,000m^2. The catchment of the proposed extension to the flood relief tunnel represents 27% of the total catchment of the valley.

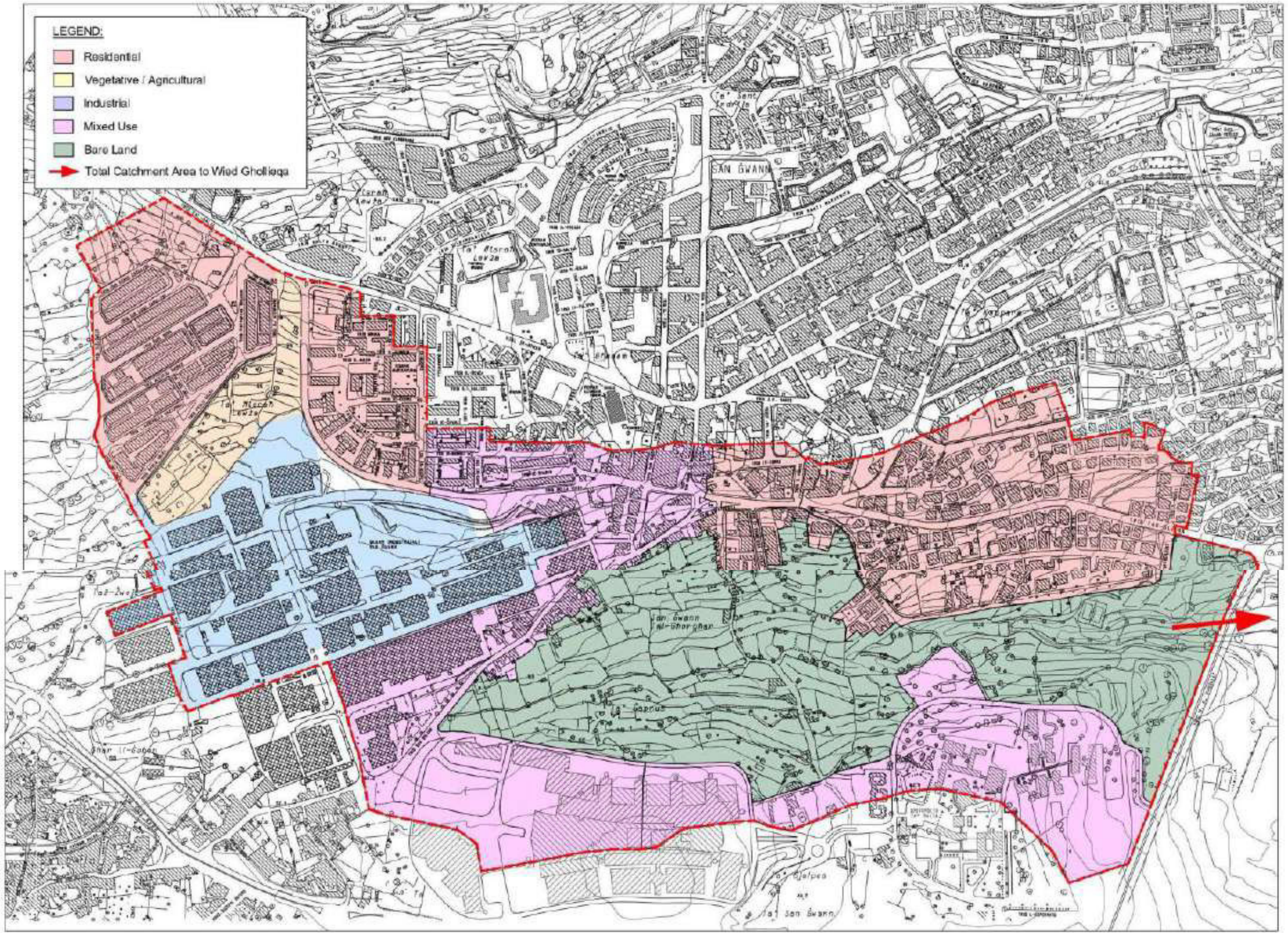


FIGURE 23: MAP SHOWING THE CATCHMENT OF WIED GĦOLLIEQA SUBDIVIDED ACCORDING TO LAND USE (SOURCE: PDS)

The time of concentration is defined as the time needed for run-off water derived from rainfall to flow from the most remote point in a watershed to the watershed outlet-the discharge point that is in this case:

- The Shaft at the industrial Estate
- The discharge point of Wied Għollieqa

To determine these criteria, it is necessary to define some terrain properties:

- the length of the flow path L,
- the catchment area, A and
- the slope of the terrain, S

of the catchment of the sites presented in Table 18.

TABLE 18: CATCHMENT PARAMETERS USED TO CALCULATE THE TIME OF CONCENTRATION OF THE SITE

	L (KM)	A (KM²)	A (HA)	S (%)
Shaft at the industrial Estate	0.67	0.3105	31	6
Wied Għollieqa	1.95	1.167	118	4

Two different formulae are used to approach the real value of time of concentration (in minutes):

- Ventura formula: $t = 76.3 \cdot \frac{\sqrt{A}}{\sqrt{S}} = 19.3\ min$
- Passini formula: $t = 64.8 \cdot \frac{\sqrt[3]{L \cdot A}}{\sqrt{S}} = 17.2\ min$

TABLE 19: TIME OF CONCENTRATION

	L (KM)	A (KM²)	VENTURA (MIN)	PASSINI (MIN)	AVERAGE (MIN)
Shaft at the industrial Estate	0.67	0.3105	17.4	15.8	16.6
Wied Għollieqa	1.95	1.167	22.2	42.6	32.4

The average time of concentration for the shaft catchment = 16.6 Minutes

The average time of concentration for runoff in Wied Għollieqa catchment = 32.4 Minutes

Even though the Rational Method has frequently been criticised for its simplistic approach, no other drainage design method has received such widespread use. It is important to note that this method is particularly adapted for areas as large as 200 acres (80 hectares).

The weighted runoff coefficient of the catchment for the proposed shaft was estimated using the formula:

$$\text{Composite C} = \frac{\sum (C_{\text{Individual Areas}})(A_{\text{Individual Areas}})}{A_{\text{Total Area}}}$$

The average storm value was taken as (103 mm/day equivalent to 0.169 inches per hour). This value represents the average of all the storm events encountered in the 42-year rainfall data acquired from the Metoffice Luqa:

- Composite C =0.69
- Storm event Im =0.169Inches/hour
- Area of the Catchment of the proposed shaft =77.2Acres

$$Q = C.Im.A = 0.69 \times 0.169 \times 77.2 = 9.0\ cfs = 255\ L.s^{-1}$$

Where: Q is the peak run-off in cubic ft per second (converted to L/s)

The same equation is used to determine the peak run-off discharge of the heavy rainfall (70mm/day) recorded:

$$Q = C.Im.A = 6.39\ CFS = 180\ L.s^{-1}$$

As for storm events (50mm/day), the following equations present the results of the peak run-off for the significant rainfall event:

$$Q = C.Im.A = 124\ L.s^{-1}$$

2.3.2 Ecological study

Wied Għollieqa is a renowned ecological location that has undergone thorough examination and comprehensive documentation in past research endeavors. As a result, this document has extensively examined the findings from these investigations to gain an improved comprehension of the ecological processes influencing the area. In particular, this report cites a 2012 AIS Environment EPS report presented on behalf of Transport Malta concerning enhancements to a Grade Separated Junction at Kappara. These findings were also substantiated by a broad-brush vegetation survey that was conducted in August 2023.

Wied Għollieqa, recognized for its ecological and scientific significance, benefits from a safeguarded status through a comprehensive network of legal and policy frameworks. These frameworks collectively ensure the preservation, research, and sustainable management of this valuable ecosystem.

1. A Special Area of Conservation and National Importance as per Government Notice 223 of 2005 and Government Notice 112 of 2007 and in accordance to NHLP Policy NHCV 01
2. A Protected Valley in accordance to NHLP Policy NHCV 01
3. A Bird Sanctuary in accordance to Schedule V of LN 79 of 2006. This legal notice repeals LN 146 of 2003, which designated Wied Għollieqa as a Nature Reserve
4. A Tree Protection Area as per Government Notice 473 of 2011
5. A Protected Area in accordance to Schedule IV of LN 12 of 2001, which has been repealed by LN 200 of 2011
6. An Area of Ecological Importance at Level 1, 2, 3, 4 and Site of Scientific Importance at Level 1 as per Government Notice 241 of 1997, amended by Government Notice 869 of 2009, in accordance to MSP Policies RCO 10(), 11(1,2,4,8), ROC 12 and NHLP policies NHCV 01, NHCV 03
7. Any trees older than fifty years present within protected areas, ODZ and UCA qualify as Protected Species in line with the provisions of S.L. 549.123.
8. Any coniferous trees present in the site or its environs are subject to the Conifer Trees (preservation) Regulations 1949 (GN. 328 of 1949)
9. The protection of species listed in Table 2 is subject to the provisions of L.N.311 of 2006 and S.L.549.123, in accordance to their listing in their relevant schedules
10. Rubble walls are protected by virtue of L.N.160 of 1997 as they provide a habitat for flora and fauna

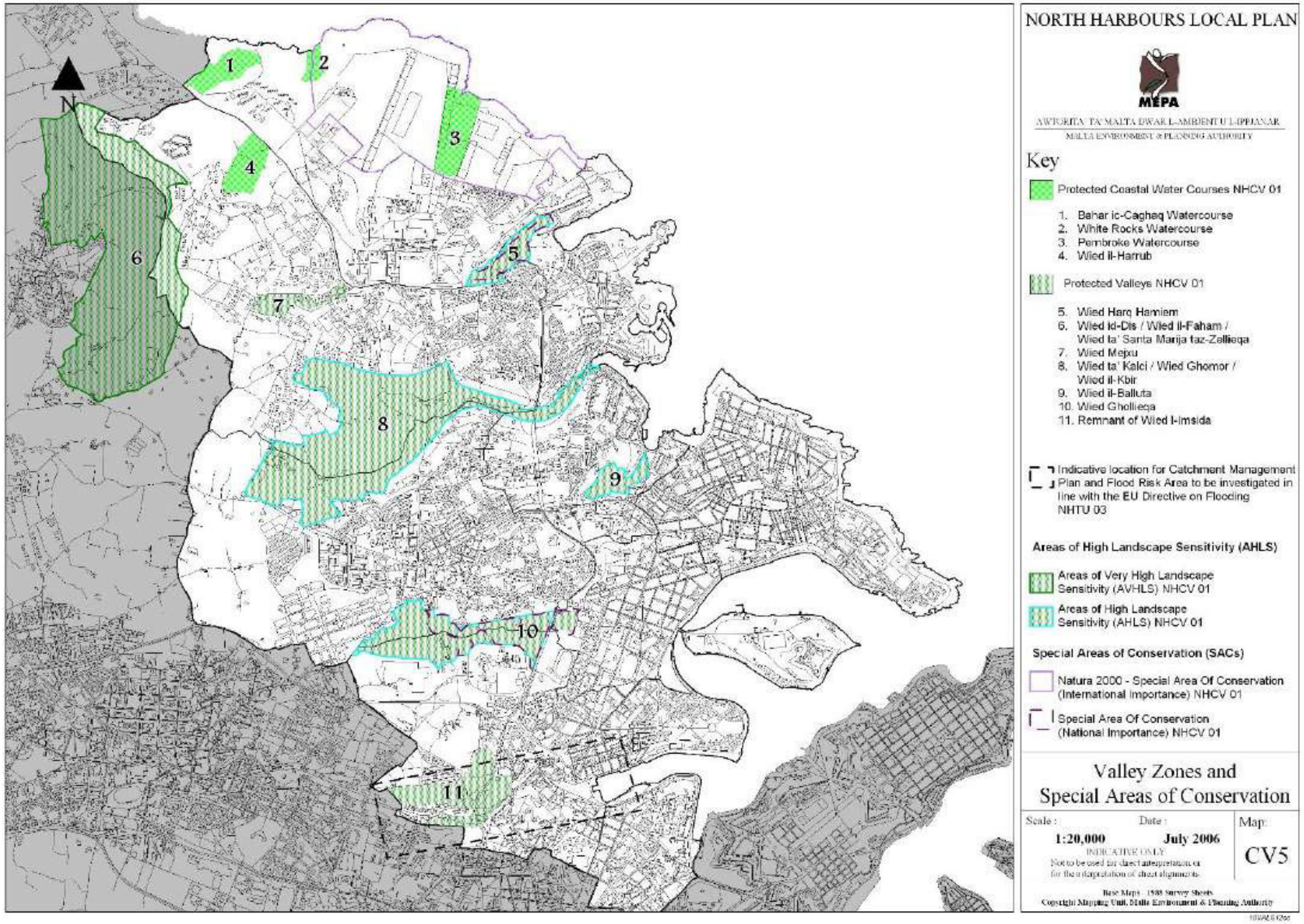


FIGURE 24: EXTENTS OF WIED GĦOLLIEQA VALLEY ACCORDING TO THE NHLP

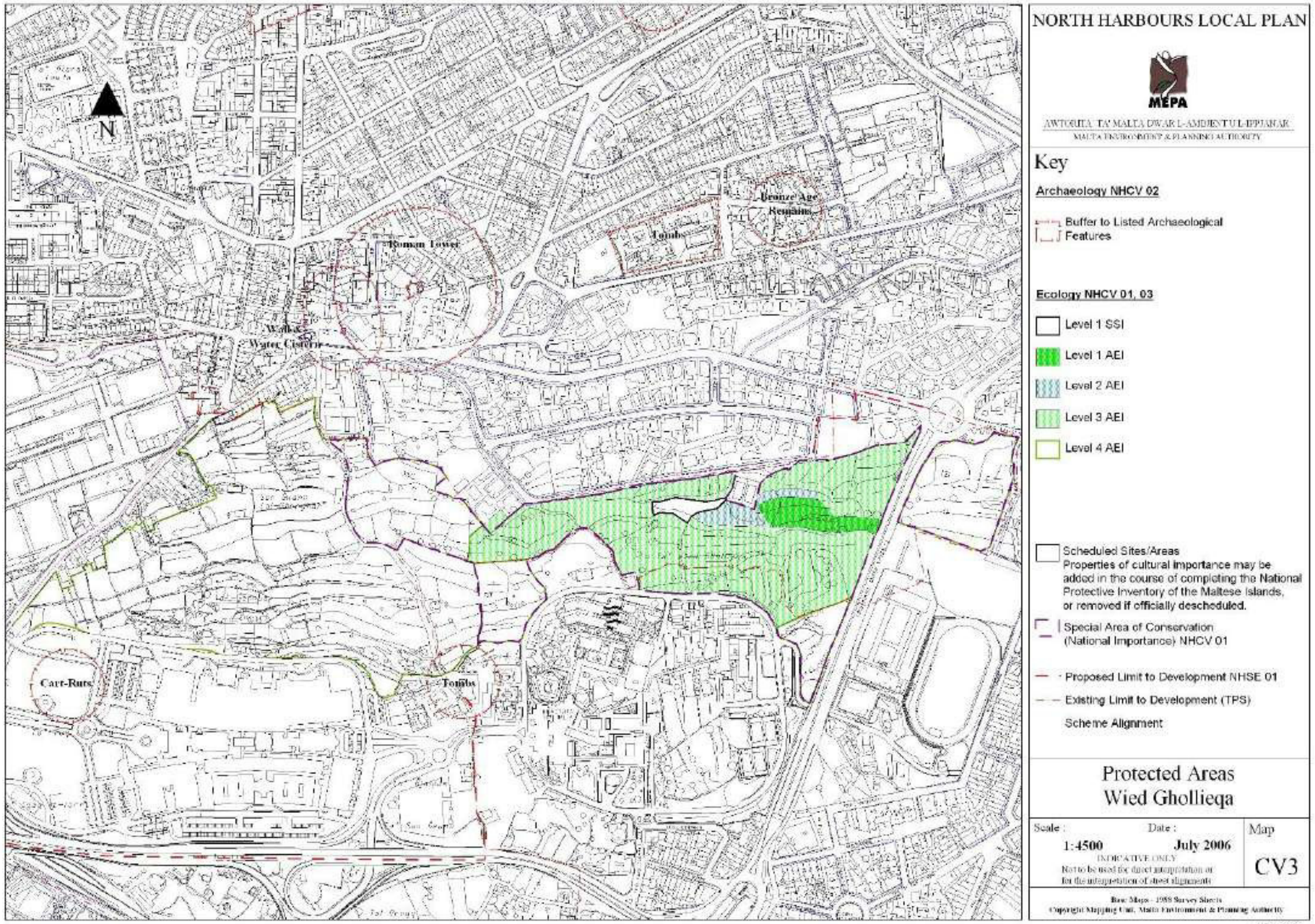


FIGURE 25: AREAS OF ECOLOGICAL IMPORTANCE (NHLP, 2006)

Wied Għollieqa harbors a diverse array of ecological assets, encompassing vital elements such as ecological habitats, safeguarded flora and fauna, sylvan expanses, and assorted natural terrain features, including cultivated land. The intricate Mediterranean valley system of Wied Għollieqa underlines the indispensable role of hydrological conditions in governing the site's ecological equilibrium. These conditions stand as fulcrums for sustaining the biological life forms inhabiting the valley. In this context, the fluctuations in precipitation that occur seasonally wield paramount influence in shaping the resident communities.

FIGURE 26: NORTHERN SECTIONS OF WIED GĦOLLIEQA SHOWING A MIXTURE OF TERRACED FIELDS AND LARGE TREES

As elucidated in the hydrology section, the site experiences substantial influxes of stormwater, which flow seamlessly from the entire catchment area in response to the gravitational forces dictated by the valley's topographic contours. This dynamic process contributes to the formation of small, localized pools of stagnant water along the fringes of the valley. Simultaneously, the main valley bed typically undergoes complete desiccation during the summer months, showcasing the cyclic nature of water availability and its profound impact on the ecosystem's functioning.

FIGURE 27: ROUTE TAKEN BY THE SEASONAL WATERCOURSE AT WIED GĦOLLIEQA

At present, the custodianship of Wied Għollieqa rests with Nature Trust Malta, an organization actively engaged in multifaceted restoration endeavors. These interventions are meticulously designed to counterbalance the detrimental effects of human activities and to elevate the conservation status of the diverse array of habitats and species existing within the ecosystem. Nature Trust Malta's proactive involvement spans a spectrum of strategic initiatives aimed at nurturing the ecological integrity of the site while fostering harmonious coexistence between the natural environment and human interactions.

FIGURE 28: WATER RUNOFF WITHIN THE VALLEY BED (SOURCE: NATURE TRUST MALTA)[2]

2.3.2.1 Vegetation assemblages

Within the valley floor of Wied Għollieqa, a prevailing natural vegetation emerges as a spacious arborescent matorral, comprised primarily of archaeophytic species. Notably, *Ceratonia siliqua*, commonly known as Carob, stands as the primary evergreen canopy tree in this context. The lower vegetation stratum is predominantly

[2] https://naturetrustmalta.org/wp-content/uploads/2010/06/29122011197.jpg

populated by deciduous shrubs, including *Crataegus monogyna* (Hawthorn) and *Rhamnus oleoides* (Olive-leaved Buckthorn). Intertwined amidst these are climbers and creepers such as *Hedera helix* (Ivy), alongside herbaceous plants like *Acanthus mollis* (Bear's breeches), *Smyrnium olusatrum* (Alexanders), and *Arum italicum* (Italian Lords-and-Ladies).

FIGURE 29: CLOSE UP VIEW OF A CAROB TREE

Further enriching the ecological tapestry are prominent climbers, including *Rubus ulmifolius*, *Smilax aspera* (Common Smilax), and the invasive *alien Cardiospermum grandiflorum* (Love-in-a-puff). The presence of *Olea europaea* (Olive), is exemplified by a pair of mature trees within Wied Għollieqa. Additionally, sporadic instances of *Ficus carica* (Fig) trees and established clusters of *Opuntia ficus-indica* (Prickly pear), flourish within this maquis community that spans the length of the valley.

Characteristic of this habitat is its tendency to generate a sheltered, dim, and moist microclimate, fostering soil enriched with fallen foliage beneath the tree canopy. This nutrient-rich environment provides sustenance to a plethora of fungi, invertebrates, and other fauna, exemplifying the intricate interplay of organisms that thrive in this ecosystem.

The role of rainwater runoff takes on a pivotal significance, especially concerning species that thrive in semi-aquatic environments. This hydrological process plays a paramount role in sustaining water-loving species within the watercourse community. Rainwater runoff acts as a life-affirming conduit, channeling essential moisture to species that have evolved to flourish in damp or even submerged conditions. This is particularly crucial in the context of Wied Għollieqa's diverse ecological makeup, where species relying on not-so-consistent water sources are intricately woven into the fabric of the ecosystem.

Transitioning to the broader watercourse community, distinctive colonization patterns come to the fore. Notably, *Arundo donax* (Great Reed) forms isolated yet robust stands, embellishing the landscape. These invasive pockets of vegetation do not contribute to the structural diversity of the ecosystem, as they tend to dominate the area and rarely offer niches for the coexistence of additional flora. Occassionally, the interspersion of *Ficus carica* (Fig) amidst the Great Reed enriches the community's biodiversity.

FIGURE 30: GREATER REED BEDS

In certain sectors of the temporary watercourse, one can encounter the presence of *Rumex conglomeratus* (Clustered Dock) and *Rumex cristatus* (Crested Dock). These species not only contribute to the community's botanical diversity but also reflect the complex interplay of historical and ecological factors that shape Wied Għollieqa. The rarity of *Rumex cristatus*, while underlined, prompts contemplation on its native status and raises intriguing questions about its origins within this environment.

Certain regions have experienced significant encroachment by the non-indigenous *Ricinus communis* (Castor oil tree), leading to a substantial deterioration in the quality of the watercourse community. These compromised areas exhibit a dual dominance, with the unregulated proliferation of *Opuntia ficus-indica* (Prickly Pear) intermingled with stands of *Prunus dulcis* (Almond) trees. Alongside these transformations, the watercourse accommodates other foreign species originating from ornamental plantings, such as *Pittosporum tobira* (Japanese Mock Orange), *Acacia karoo* (Thorn

Acacia), and *Mirabilis jalapa* (Marvel-of-Peru). All of these species are easily transported by avifauna present at the valley and rainwater runoff.

FIGURE 31: INVASIVE TREES ARE A COMMON OCCURRENCE AT THE PERIMETER OF THE VALLEY

The remaining land within Wied Għollieqa is primarily characterized by fields enclosed by rubble walls. Notably, the fields located in the northern and eastern regions of the valley continue to serve active agricultural purposes. These areas are typically plowed during the dry season. Within these freshly cleared spaces, a profusion of dry-season herbs thrives, including *Hypericum triquetrifolium* (Crisped St. John's wort), *Heliotropium europaeum* (Common Heliotrope), and *Delphinium halteratum* (Winged Larkspur).

On the abandoned agricultural land towards the southern side, a distinctive ruderal community has taken root, characterized by species commonly found in steppe and ermes habitats. Within this ecosystem, a diverse array of flora thrives, contributing to the habitat's rich botanical diversity. Among the prominent inhabitants are perennial shrubs like *Dittrichia viscosa* (Sticky fleabane), *Asparagus aphyllus (*Spiny asparagus), and *Capparis orientalis* (Caper), which are resilient components of this environment.

This community also features *Senecio bicolor* (Silver Ragwort), alongside grasses such as *Hypparhenia hirta* (Hispid beard grass) and *Stipa capensis* (Mediterranean Steppe-grass). Adding to this botanical medley are the presence of *Foeniculum vulgare* (Fennel) and *Daucus carota* (Wild carrot), along with the distinctive thistle *Galactites tomentosa* (Boar thistle).

Under the stewardship of NTM, efforts have been made to transform abandoned fields into thriving woodlands. This reforestation initiative has led to the establishment of a diverse range of tree species including *Tetraclinis articulata* (Sandarac Gum Tree), *Pinus halepensis* (Aleppo Pine), *Quercus ilex* (Holm Oak), and *Cupressus sempervirens* (Cypress). Nowadays, the valley encompasses one of the largest populations of the endangered national tree, *Tetraclinis articulata*. [3]

FIGURE 32: THE SANDARAC GUM TREE, THE DWARF FAN PALM TREES AND OTHER MATURE TREES AT THE NORTH-EASTERN ZONES

The university precincts, within their boundaries, feature extensive tree plantations encircling the ring road. These plantations predominantly consist of *Pinus halepensis* (Aleppo Pine), *Acacia karoo* (Thorn Acacia), *Cupressus sempervirens* (Cypress), and *Eucalyptus camaldulensis (*Red Gum Tree). It's worth noting that *Olea europaea* (Olive) trees have also been widely introduced, contributing to the green landscape that these areas have been thoughtfully cultivated to embody.

In generic terms, the habitats occupied within Wied Għollieqa can be described by the PHYSIS Palaearctic Habitat Classification (Devillers – Tershuren & Devillers, 2001):

11. 32.122: Carob arborescent matorral
12. 32.9: Ermes

[3] https://naturetrustmalta.org/what-we-do/natural-parks/wied-ghollieqa/

13. 34.8: Mediterranean sub-nitrophilous grasslands
14. 87.2: Ruderal communities
15. 34.64: Cane steppe
16. 82.3: Extensive cultivation
17. 34.31: Conifer plantations
18. 83.32: Plantations of broad-leaved trees

The following table provides an exhaustive list of the species encountered within the valley system, along with their protection status, as may be applicable:

TABLE 20: LIST OF SPECIES RECORDED AT THE VALLEY

SPECIES NAME	VERNACULAR NAME	PROTECTION STATUS
Pinus halepensis	Aleppo Pine	First Schedule Part A Table 2 S.L. 549.123
Tetraclinis articulata	Sandarac Gum Tree	First Schedule Part A Table 1 S.L. 549.123
Populus alba	White Poplar	First Schedule Part A Table 2 S.L. 549.123
Quercus ilex	Evergreen oak	First Schedule Part A Table 1 S.L. 549.123
Capparis orientalis	Caper	Schedule VI of S.L.549.46
Ricinus communis	Castor Oil tree	Second Schedule S.L.549.123
Crataegus monogyna	Hawthorn	First Schedule Part A Table 2 S.L. 549.123
Acacia saligna	Blue-leaved Acacia	Second Schedule S.L.549.123
Acacia karoo	Thorn Acacia	Second Schedule S.L.549.123
Ceratonia siliqua	Carob	First Schedule Part A Table 2 S.L. 549.123
Cercis siliquastrum	Judas tree	First Schedule Part A Table 2 S.L. 549.123
Leucaena leucocephala	Lead tree	Second Schedule S.L.549.123
Eucalyptus camaldulensis	Red gum tree	Second Schedule S.L.549.123
Pittosporum tobira	Japanese Mock Orange	Second Schedule S.L.549.123
Rhamnus oleioides	Olive-leaved Buckthorn	First Schedule Part A Table 1 S.L. 549.123

SPECIES NAME	VERNACULAR NAME	PROTECTION STATUS
Olea europaea	Olive tree	First Schedule Part A Table 2 S.L. 549.123
Phlomis fruticosa	Great Sage	-
Rosmarinus officinalis	Clustered Carline Thistle	-
Chamaerops humilis	Mediterranean dwarf palm	First Schedule Part A Table 2 S.L. 549.123
Phoenix dactylifera	Date palm	First Schedule Part A Table 2 S.L. 549.123
Adiantum capillus-veneris	Maidenhair fern	-
Cupressus sempervirens	Cypress	-
Delphinium halteratum	Winged larkspur	-
Ranunculus muricatus	Scilly buttercup	-
Papaver dubium	Long-headed poppy	-
Vitex vinifera	Grape vine	-
Ficus carica	Fig	-
Parietaria Judaica	Pellitory-of-the-wall	-
Urtica dubia	Large-leaved nettle	-
Opuntia ficus indica	Prickly pear	-
Amaranthus blitoides	Prostrate pigweed	-
Atriplex prostate	Spear-leaved orache	-
Silene vulgaris	Bladder campion	-
Rumex conglomeratus	Clustered dock	-
Rumex cristatus	Crested dock	-
Hypericum triquetrifolium	Crisped St John's wort	-
Diplotaxis tenuifolia	Perennlia wall-rocket	-
Sinapsis alba	White mustard	-
Lavatera arborea	Tree mallow	-
Euphorbia pinea	Pine spurge	-
Mercurialis annua	Annual mercury	-
Cardiospermum grandiflorum	Love-in-a-puff	-

SPECIES NAME	VERNACULAR NAME	PROTECTION STATUS
Prunus dulcis	Almond	-
Hippocrepsis multisiliquosa	Common horseshoe vetch	-
Lotus ornithopodioides	Common birsfoot trefoil	-
Medicago intertexta	Calvary medick	-
Medicago littoralis	Coastal medick	-
Medicago orbicularis	Disk medick	-
Punica granatum	Pomegranate	-
Tropaeoleum majus	Garden nasturtium	-
Oxalis pes-caprae	Cape sorrel	-
Geranium purpureum	Purple herb Robert	-
Convolvulus arvensis	Field bindweed	-
Hedera helix	Ivy	-
Daucus carota	Wild carrot	-
Ferula communis	Giant fennel	-
Foeniculum vulgare	Fennel	-
Smrnium olusatrum	Alexanders	-
Galium aparine	Cleavers	-
Nerium oleander	Oleander	-
Acanthus mollis	Bear's breeches	-
Borage officinalis	Borage	-
Heliotropium europaeum	Common heliotrope	-
Lantana camara	West Indian Lantana	-
Ajuga pseudoiva	Yellow southern bugle	-
Mentha pulegium	Penny royal	-
Bougainvillea x spectabilis	Bougainvillea	-
Mirabilis jalapa	Marvel-of-Peru	-
Antirrhinum siculum	Sicilian snapdragon	-
Orobanche spp.	Broom rapes	-

SPECIES NAME	VERNACULAR NAME	PROTECTION STATUS
Carlina involucrata	Clustered Carline thistle	-
Carthamus lanatus	Wooly safflower	-
Cichorium intybus	Chicory	-
Conzya bonariensis	South American Fleabane	-
Dittrichia viscosa	Sticky fleabane	-
Galactites tomentosa	Boar thistle	-
Glebionis coronaria	Crown daisy	-
Hypochoeris achyrophorus	Mediterranean catsear	-
Lactuca serriola	Prickly lettuce	-
Pallenis spinosa	Spiny ox-eye daisy	-
Senecio bicolor	Silvery ragwort	-
Sonchus oleraceus	Smooth sow-thistle	-
Allium commutatum	Wild leek	-
Asphodelus aestivus	Branched asphodel	-
Asparagus aphyllus	Spiny asparagus	-
Yucca gloriosa	Spanish dagger	-
Smilax aspersa	Common smilax	-
Phoenix canariensis	Canary date palm	-
Chasmanthe aethiopica	Cobra lily	-
Arundo donax	Greater reed	-
Avena sterilis	Animated oat	-
Bromus madritensis	Compact brome	-
Bracypodium distachyum	Purple false brome	-
Cynodon dactylon	Bermuda grass	-
Dactylis hispanica	Cock's foot	-
Hordeum leporinum	Hare's tail barley	-
Hyparrhenia hirta	Hispid beard-grass	-
Lagurus ovatus	Hare's tail grass	-

SPECIES NAME	VERNACULAR NAME	PROTECTION STATUS
Phalaris minor	Lesser canary grass	-
Piptatherum miliaceum	Rice-grass	-
Rostraria cristata	Mediterranean hair grass	-
Setaria adhaerens	Bur Bristel grass	-
Sorghum halepense	Johnson grass	-
Stipa capensis	Mediterranean steppe-grass	-
Arum italicum	Italian Lords and Ladies	-

2.3.2.2 Fungi

The valley system at Wied Għollieqa encompasses a wide diversity of fungi, cited by Briffa and Lanfranco (1986) as one of the three richest stations for mycoflora in the Maltese islands. Whilst a survey on fungi has not been carried out as part of this study due to its time restraints, this report lists down the fungal records which have been reported in the area by AIS in the Kappara EPS Report (2012).

It is of considerable significance to recognize that the majority of fungi inhabiting the ecosystem of Wied Għollieqa exhibit symbiotic associations primarily with carob trees, and to a somewhat lesser degree, with prickly pear plants. As a result, the wellbeing and richness of fungal biodiversity within Wied Għollieqa are intricately intertwined with the prevailing health and condition of the carob tree population. Consequently, the preservation and vitality of the carob tree population are pivotal factors governing the robustness and conservation of fungal diversity within the Wied Għollieqa ecosystem. Recent afforestation events in the area seek to support the mycoflora communities within the valley system.

19. *Inonotus indicus,* typically grows from the roots or base of trunks of carob trees
20. *Crepidotus haustellaris,* grows from the trunk of carob trees
21. *Daldinia concentrica,* dead branches, mostly of carob trees
22. *Coriolopsis gallica,* associated with carob trees
23. *Fomes fomentarius,* growing from carob tree trunks
24. *Auricularia auricula-judae,* associated with carob trees
25. *Ganoderma* sp, growing on live carobs and hawthorn
26. *Laetiporus sulphureus,* on carob trees
27. *Phellinus sp.,* on old carob tree
28. *Peziza proteana,* observed near a burn carob stump
29. *Psathyrella melanthina,* beneath prickly pears and carobs
30. *Pleurotus opuntiae* on remains of prickly pear

31. *Coprinus picaceus,* on decaying remains of prickly pear
32. *Psathyrella spintrigera,* underneath frondrose trees
33. *Peziza vesiculosa*, in compost
34. *Volvariella speciosa,* among grass
35. *Agaricus* sp., amongst grass
36. *Stereum* sp., on dead carob twigs
37. *Coprinus* sp., on burnt wood

The Schedule VI of L.N.311 of 2006 fungal species, *Boletopsis grisea* and *Sacrosphaera cornoaria* were not identified during previous surveys in the area as these fungi are typically associated with mature conifers.

2.3.2.3 Fauna

The valley system is designated as a bird sanctuary to protect a number of wintering, breeding and migratory bird species. The most common species encountered include the Sardinian Warbler (*Sylvia melanocephala),* Cetti's Warbler (*Cettia cetti),* and the Common Swift (*Apus apus).*

Reptile and amphibian sightings have been reported from the valley, comprising primarily of *Coluber viridflavus* (Black whip snake), *Discoglossus pictus pictus* (Painted frog), *Podarcis filfolensis maltensis* (Maltese wall lizard), *Chalcides ocellatus* (Oscillated skink) and *Tarentola mauritanica* (Moorish Wall Geckoes). Records of the weasel (*Mustela nivalis*) have also been made at the valley. The distribution of this rare mammal has been significantly influenced by habitat fragmentation and is therefore recognised as a protected species.

3 IMPACT ASSESSMENT

3.1 CONSTRUCTION PHASE

The planned construction activities envisioned at the San Ġwann Industrial Estate, involving the integration of a vertical access shaft and extension of the pre-existing NRFP tunnel along Triq Dun Karm Psaila in B'kara, are poised to exert minimal, if any, detrimental and significant effects upon the Wied Għollieqa valley system.

This statement is substantiated by the notable spatial separation that demarcates the project works from the valley system. Furthermore, it is imperative to underscore that the majority of these construction works are planned below ground level. This inherently mitigates the prospects of indirect adverse impacts that might emanate from surface runoff contamination, spillover effects, trampling, ground contamination or the aerial dissemination of particulate matter from the construction site.

In addition to the site's spatial remoteness, the extensive array of anthropogenic activities surrounding the valley collectively act as a buffer to mask any noise that might ensue from the proposed construction. This setting effectively diminishes any conceivable concerns over noise-induced disturbances to the valley's biological constituents, particularly its fauna and avifauna.

Consequently, the above conditions render further reinforces the notion that the proposed construction works hold an insignificant adverse impact on the ecological integrity of the Wied Għollieqa valley system.

3.2 OPERATIONAL PHASE

The project is intended to divert the stormwater runoff generated from the Industrial Estate of San Ġwann and from Ta' Żwejt residential area into the proposed underground tunnel, to connect with the existing Birkirkara Catchment Flood Relief Tunnel. As specified earlier, this diversion aims to reduce the occurrence of flooding which currently takes place at Triq Sir Anthony Mamo and the roads leading to the main entrance of Mater Dei.

This also implies that the total amount of runoff within the Gżira Catchment, which is currently collected within the soakaway reservoir at the end of Wied Għollieqa, is envisaged to decrease due to this project. The proposed tunnel intervention does not aim to collect all the stormwater from the area, however the runoff flowing into the natural valley is expected to reduce in volume. Measurements of the catchment area show that 27% of the total catchment area shall be diverted into the Birkirkara Catchment Flood Relief Tunnel through the proposed tunnel. Thus, the runoff flowing into the natural valley Wied Għollieqa shall also be reduced by volumes which depend on the rainfall intensity.

A reduced volume of runoff towards the valley can lead to the valley becoming increasingly prone to xeric conditions that could alter its ecological dynamics. A 27% runoff diversion is considered to comprise a significant volume. The impact will be most significant at the outer western stretches of the valley which are closest to the Mater Dei Hospital roundabout and primarily comprise of agricultural land. The proposed intervention is therefore likely to influence agricultural productivity in the area, as farmers are known to rely on the harvesting of rainwater from the valley's watercourse. As rain intensity increases during severe storms, residual surface water runoff which is not captured by the NFRP tunnel is more likely to reach the western perimeter of the valley and supply the agricultural land in the area.

The significance of this impact is expected to reduce gradually as one transitions deeper into the valley system from a western to eastern direction. These are supplied with surface runoff water originating from other water catchment areas situated around the valley's perimeter i.e. the remaining 73%. This runoff originates from the valley basin itself, the University of Malta campus, sections of the Industrial Estate, Triq San Ġiljan and certain residential areas in San Ġwann and Kappara.

Furthermore, it is pertinent to note that the most ecologically sensitive areas are located at the eastern and central portions of the valley system. These areas of ecological importance are positioned at a considerable distance from the Industrial Estate and are therefore supplied by alternative water courses around the perimeter of the valley. As previously stated, the volume of storm water runoff arriving from the San Gwann Industrial catchment and into these areas must first pass through the western agricultural fields whose soils tend to absorb a considerable fraction of the water. Furthermore, the valley does not comprise of permanent water streams or temporary fresh water rock pools, implying that the valley system is already attuned to desiccating conditions.

With the implementation of the project, one may expect some minor fluctuations in the valley's microclimate, such as humidity levels and temperature. This may be attributed to the slight reduction in water availability, thus shortening the periods and intensity of plant transpiration. Transpiration entails the movement of water through a plant, followed by its subsequent evaporation into the atmosphere from the plant's leaves, stems, and flowers. This process typically releases about 97-99% of the water absorbed by flora. This effect causes transpiration cooling of the environs and also contributes significantly towards maintaining high humidity and damp conditions within the valley system.

Nevertheless, one must also remark that the water diverted towards the proposed NFRP tunnel is likely polluted or contaminated with hydrocarbons, since it mainly originates from the San Ġwann Industrial Estate area. This implies that the rainwater runoff passing through the valley is less likely to be contaminated, thus reducing the potential accumulation of pollutants within the valley's soil bed.

The ecological communities within the Wied Għollieqa valley are not strictly dependent on the continuous presence of a watercourse system. No species associated with permanent water courses or temporary freshwater rockpools have been encountered in the area. In fact, the valley has been gradually dominated by hydrophilic invasives such as *Arundo donax* which tend to conglomerate next to the valley's temporary watercourse routes. Such reeds are able to survive xeric conditions better than native alternatives due to their water storage potential.

Other commonly encountered trees such as *Ceratonia siliqua*, which have been identified as keystone species for the mycoflora biodiversity within the valley system, are known to grow and adapt to a wide variety of abiotic conditions in the Maltese islands ranging from farmland to garigue habitats.

Such observations suggest that the most important ecological elements of the valley are able to adapt to a reduction in runoff water volumes and that the overall impact from the project is not expected to be significant. A series of mitigation measures and recommendations have been put forward to ensure that the predictions made are factual and to circumvent any issues encountered during the operational phase.

3.3 Decommissioning phase

Tunnel decommissioning involves ceasing its utilization and discontinuing its operational activities. In situations involving the decommissioning of a water tunnel, the usual course of action involves detaching it from the original source or network to which it was connected, followed by a choice between its burial or retention. In the specific case of the tunnel under consideration, the prospect of burying it is improbable due to various factors.

Primarily, the tunnel demands minimal maintenance and does not contain any perilous substances that could induce enduring harm to the surroundings. Furthermore, the burying of the tunnel would entail substantial expenses encompassing financial outlay and ecological repercussions. The act of burying a tunnel necessitates a noteworthy allocation of resources, inclusive of specialized machinery and proficient personnel.

Lastly, the decision to leave the tunnel in its current position does not cause notable threats to human well-being or the ecosystem. The tunnel's influence on the local biome remains marginal. Consequently, the motivation or rationale for eliminating the tunnel is inadequate, given the elevated expenses and the potential adverse environmental ramifications that such an action could yield.

4 MITIGATION MEASURES

In order to avoid indirect impacts on ecologically important areas, the implementation of diligent working practices and mitigation measures are still required. The ENVIRONMENTAL MANAGEMENT CONSTRUCTION SITE REGULATIONS (S.L. 522.09) should be enforced to avoid the impacts from being generated in the first place and to ensure that environmental degradation is kept as low as possible. These regulations provide details on the containment and transportation measures for loose construction material on site and in transit, and other measures to prevent carrying out and/or depositing particulate matter.

Chemical spillages from machinery should be avoided by storing wastes and chemicals in bunded areas within the construction site. All construction debris and soil should be stockpiled in temporary areas away from sensitive watercourses or areas prone to flooding.

Negligence during construction activities can be mitigated through regular and effective environmental monitoring to ensure that the construction impacts are not spilling over into the adjacent habitats.

Hoarding and wheel wash facilities should be set up (in line with the ENVIRONMENTAL MANAGEMENT CONSTRUCTION SITE REGULATIONS, 2007) along the construction site access points to minimise dispersion of particulates. This should be covered with suitable mesh or material that precludes dispersion of particulate matter.

Pre-soaking, dust suppressors and covered stockpiles are considered good practices to minimise dust emissions. Construction vehicles and machinery should be well-maintained and serviced such that they can be operated at the best of their environmental performance.

5 RESIDUAL IMPACTS

Residual impacts are those impacts which are bound to remain after taking into consideration the proposed mitigation measures. Despite the comprehensive adoption of the recommended mitigation measures, a number of unavoidable residual impacts are still expected to arise, namely:

- Reduction in stormwater runoff volumes towards the valley system
- A slight modification in microclimate conditions due to reduced transpiration effects

The above impacts are not considered to be significant. The Scheme is therefore not expected to have a significant detrimental effect on the integrity of the site.

6 Monitoring Programme

If the Scheme is authorized for development, the establishment and execution of a monitoring initiative become imperative during the active stages of the project. It is strongly advised that a qualified specialist oversee the observation of runoff water movement within the valley to verify the effective realization of the predictions outlined in this report.

In light of this, it is recommended that comprehensive surface runoff data within the valley network be documented before the tunnel's commissioning, enabling the acquisition of real-time information. This data would then serve as a benchmark against which the seasonal assessment of rainwater runoff throughout the operational lifespan of the Scheme could be measured. Open and productive communication with the Nature Trust Malta (NTM) will be pivotal to ensure the perpetuity of the site's integrity, particularly concerning the preservation of species and habitats within the vicinity.

7 Summary of Impacts Table

Impact type and source			Impact receptor		Effect & Scale							Probability of impact occurring	Overall impact significance	Proposed mitigation measures	Residual impact significance	Other requirements
Impact type	Specific intervention leading to impact	Project phase	Receptor type	Sensitivity & resilience toward impact	Direct/ Indirect/ Cumulative	Beneficial / Adverse	Severity	Physical/ geographic extent of impact	Short-/ Medium-/ Long-term	Temporary / Permanent	Reversible / Irreversible					
Generation of dusts, noise and waste material	Construction activity at access point	Construction	Vegetation & faunal species outside of Wied Ghollieqa	Moderate	Direct	Adverse	Moderate	Localised	Short-term	Temporary	Reversible	Unlikely	Not significant	Adherence to S.L. 522.09	Not significant	N/A
Reduction in stormwater runoff towards the valley system	New NFRP tunnel and shaft	Operational	Vegetation & faunal species at Wied Ghollieqa	Moderate	Direct	Adverse	Moderate	Localised	Long-term	Permanent	Reversible	Inevitable	Not Significant	Monitoring of rainwater runoff within the valley system and assessing how the ecological dynamics of the valley change over time	Not significant	N/A
Reduction in humidity and cooling effects	New NFRP tunnel and shaft	Operational	Vegetation & faunal species at Wied Ghollieqa	Moderate	Indirect	Adverse	Moderate	Localised	Long-term	Permanent	Reversible	Likely	Not significant	Measuring microclimatic conditions and observing ecosystem behaviour over time	Not significant	N/A
Reduction in polluted waters	New NFRP tunnel and shaft	Operational	Soil & wildlife	Moderate	Direct	Beneficial	Moderate	Localised	Long-term	Permanent	Reversible	Likely	Not significant	N/A	Not significant	N/A

8 ALTERNATIVE SOLUTIONS

8.1 ALTERNATIVE SITES

Since the project is designed to deal with a flooding issue specific to Triq Sir Anthony Mamo and Triq San Ġiljan next to Mater Dei Hospital, no other sites were considered.

Since the proposed vertical shaft will only provide limited access from the street level to the proposed tunnel, the tunnel boring machinery will require alternative means of access during the envisaged works. Consequently, the applicant has considered three possible alternative access sites which would allow the machinery to reach the excavation face of the tunnel. All access site options are located within the existing NFRP tunnel system:

1. Access Point A (Attard (Tal-Ħofra) off Triq il-Belt Valletta

This access point is situated at the greatest distance from the Scheme site, spanning approximately 9 kilometers. Despite this substantial separation, it boasts ample dimensions that can readily accommodate the seamless transit of heavy-duty vehicles. Consequently, this location presents a notable benefit by facilitating the direct loading of excavated material onto these robust trucks, thereby eliminating the need for interim storage facilities outside the access point.

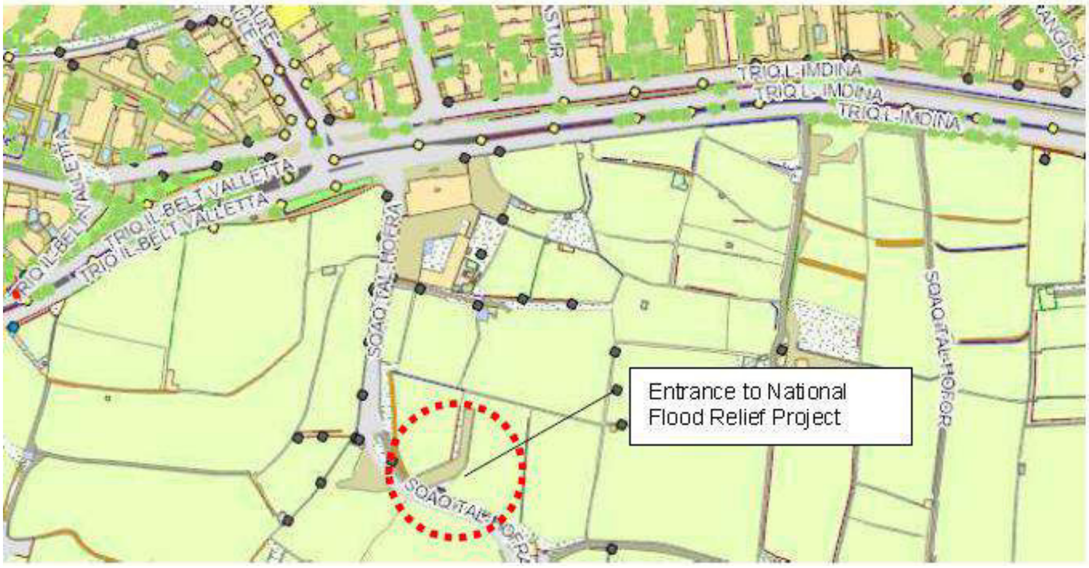


FIGURE 33: ACCESS POINT A – ATTARD

2. Access Point B – Mosta off Vjal l-Indipendenza

Access Point B occupies a strategic position within the expansive confines of the NFRP Maintenance Depot, boasting dimensions conducive to the project's requirements. Despite its commendable size and appropriateness, the attractiveness of this option is somewhat diminished due to the ongoing operations conducted within the depot. The physical separation between the proposed construction activities and the ongoing depot operations also introduces a degree of complexity to this alternative.

However, it's imperative to acknowledge that this access point does hold significant value in contingencies and urgent situations that could emerge during the course of the envisaged drilling operations. In such critical scenarios, Access Point B assumes a pivotal role as an emergency resource, standing ready to be utilized effectively as necessitated by unforeseen circumstances.

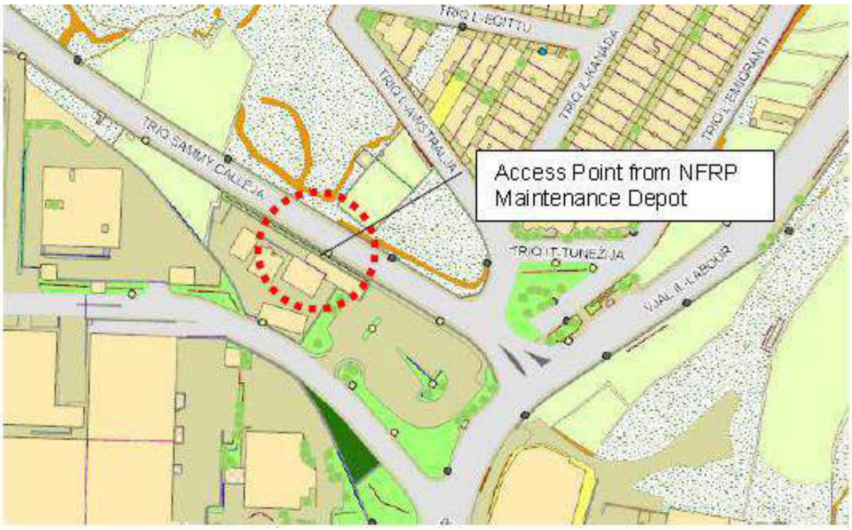


FIGURE 34 – ACCESS POINT B - MOSTA

3. Access Point C – Gżira off Triq G.Miċeli

This access point stands out as the optimal choice due to its advantageous proximity to the project site. Situated adjacent to the Kappara Junction, the entry and exit point is an integral component of the NFRP project situated at the lower terminus of Wied Għollieqa. In immediate proximity lies a substantial 10,000m^3 soakaway reservoir, whose roof will serve a dual purpose as a temporary construction site housing essential facilities and storage zones indispensable for the undertaking.

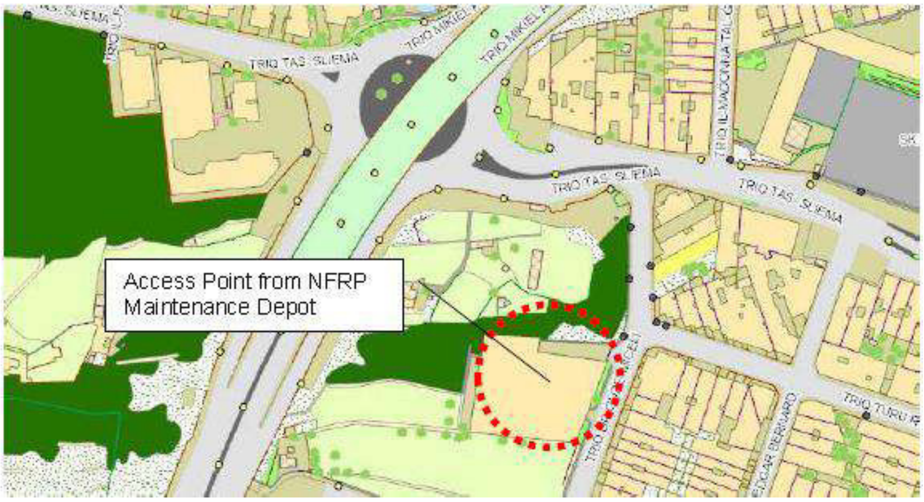


FIGURE 35: ACCESS POINT C – GŻIRA

8.2 ALTERNATIVE TECHNOLOGIES

Two alternative technologies were considered for the excavation of the tunnel, as listed hereunder:

1. Excavation of a horizontal trench which would then be covered following construction of the tunnel;
2. The use of tunnel boring machines;

The use of tunnel boring machines was selected as the most viable option since this would avoid surface trenching, achieving the ideal tunnel width and minimise the waste generated from the excavation works. Such machinery is electro-hydraulically powered and do not emit any fumes. They also encompass various modular parts that cater for particular diameters and tasks, allowing for a greater degree of flexibility when excavating tunnels. With proper geological monitoring, mitigation and compensation measures the impacts from excavation can be adequately controlled.

8.3 DOWNSCALING OF THE PROJECT OR ELIMINATION OF PROJECT COMPONENTS

The project has already contemplated the possibility of reducing its scale by devising a tunnel with the capacity to manage stormwater runoff stemming from a 1 in 1 year storm incident. This fundamental design parameter equates to a rainfall occurrence of 4m3/s (4,000L/s), which would redirect approximately 20 to 30% of the stormwater runoff. While it was feasible to develop a tunnel capable of handling more intense storm events such as 1 in 5 years, 1 in 10 years, or even 1 in 50 years, adopting such elevated design criteria would have introduced supplementary concerns relating to the indirect hydrological consequences impacting Wied Għollieqa.

As a result, the proposed tunnel is meticulously structured to mitigate flooding at the roundabout intersection leading to Mater Dei, particularly during the majority of rainfall instances that transpire throughout the year. This targeted approach is anticipated to enhance the flow of traffic and accessibility to the hospital, particularly during inclement weather conditions.

8.4 Zero Option (do-nothing scenario)

In the event that the proposed scheme is not implemented, the prevalent flooding difficulties observed along Triq Sir Anthony Mamo are projected to persist. It should be noted that the overall hydrological equilibrium within Wied Għollieqa would remain unaffected by this scenario.

Considering the pivotal significance of Triq Sir Anthony Mamo as a critical nexus of vehicular transportation, facilitating passage to vital institutions such as Mater Dei Hospital, the University of Malta, the Life Sciences Park, and the San Gwann Industrial Estate, the 'zero option' stands as a less desirable choice. Unimpeded accessibility to these pivotal zones during inclement weather conditions is essential. This is of paramount importance not only due to its impact on a substantial volume of commuters but also due to the direct ramifications for patients in emergency scenarios, where seamless access can significantly enhance their chances of survival. Thus, given these critical considerations, the 'zero option' is not viewed as a favorable course of action.

8.5 Hybrids/combination of the above

Hybrid or integrated alternatives for the aforementioned technologies are currently absent. The absence of such hybrid choices could stem from a range of factors, including technical limitations, ecological concerns, financial viability, or regulatory prerequisites.

9 CONCLUSIONS

The envisaged expansion of the NFRP tunnel represents a proactive intervention aimed at alleviating flooding concerns along Triq Sir Anthony Mamo. The primary objective is to mitigate the disruptions experienced at a pivotal intersection that directly connects to the National Public Hospital, as well as other critical commercial and educational precincts. This undertaking is poised to effect approximately 27% of the runoff amassed from the water catchment zone being redirected into the tunnel. This engineered diversion holds the potential to restrict the quantity of surface water runoff that typically nourishes the proximate Wied Għollieqa valley system.

The assessment reveals that the ecological dynamics within the valley have progressively adapted to extended periods of desiccation over time due to habitat fragmentation and over development. This is evinced by the conspicuous absence of a permanent watercourse, the scarcity of freshwater rock pools, and the limited presence of hydrophilic plant life. Thus, based on these discernible conditions, the report draws the conclusion that the proposed project is unlikely to usher significant effects upon the valley's ecological systems.

Although modest deviations might be discernible in the microclimate due to reduced transpiration rates and attenuated freshwater flows, it is notable that the overall quality of water within the valley's catchment is anticipated to experience improvement through the project. The improved water quality enhances the ecological prospects of the valley's ecosystem, underscoring the holistic effects and implications of the project's execution.

APPENDIX I

TERMS OF REFERENCE