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INCREASING CLIMATE RESILIECY OF KENYA'S ROAD NETWORK

INTERIM REPORT 2

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1 Introduction

This report continues the work from Interim Report 1. Interim Report 1 focused on the available background information ,necessary to perform a vulnerability assessment for climate change on a selected corridor in Kenya. Interim report 1 also included a detailed assessment of the natural hazards that are anticipated along the corridor as well as highlighting where key assets are located. Interim Report 2 draws on the information described in Interim Report 1 by outlining guidelines for conducting a Vulnerability Assessment along other corridors in Kenya.

Also included in Interim Report 2 are results from a site visit that was conducted along the entire corridor. Detailed priority interventions at certain locations along the corridor have been suggested based on the results from the site visit, the available design reports, and the vulnerability assessment from Interim Report 1.

Interim Report 2 also includes an analysis of the disruption costs from a closure to the road. These costs are calculated from projected traffic numbers from the design reports.

2 Site Visit

2.1 Description of Site Visit

Norken International conducted a site visit along the corridor from Isiolo to Mandera, starting on May 28th, 2018. The site visits were repeatedly delayed due to the above average rainfalls experienced during the spring of 2018. Much of the corridor is impassable during the rainy season, and numerous washouts were experienced by the site visit team.

The NETIP corridor traverses the counties of Isiolo, Meru, Wajir and Mandera. The road is generally graveled. Roads within Isiolo town are tarmacked. The tarmac extends to about 8km to a police station called Seventy Eight along the NETIP corridor. From the police station, the gravel road proceeds to Wajir town, with drifts, culverts and bridges crossing at different locations. The roads within Wajir town are tarmacked to a radius of 25km. The gravel road from Wajir to Elwak is dominated with long sections of sand deposits along the road. From Elwak towards Rhamu, the road is tarmacked to about 12km, to a centre called Corner S. The road from Elwak to Rhamu is under construction to bitumen standards. The Ministry of Defense provides funds for the construction. The section from Wargadud to Rhamu (a section of about 35km) is also tarmacked. The road from Rhamu to Mandera is generally graveled and is considerably undermined by the storm water. The roads within Mandera town are tarmacked and in good condition.

Of the total length of corridor investigated, the section between Wajir and Elwak proved to be the most challenging in terms of security, due to its proximity to the Somali border. Therefore, fewer photos were taken, since the security agencies advised the team to drive at high speeds and to have a minimum number of stops along this section.

Nevertheless, a comprehensive study was undertaken of the NETIP corridor, and photos were put together indicating the main hazard areas along the corridor. The photos taken were geo-referenced to indicate the position and direction in which the photo was taken.

The main hazards identified along the NETIP corridor are flooding and erosion. Extreme high temperatures may play a role for maintenance activities, as well as design of proper pavement surfaces. In addition to the natural hazards, security plays an important role, which limits the amount of time available and ease of mobilizing maintenance and construction crews.

The site visit was taken after a heavy rain season and shows the damages inflicted by this season's flooding. There are no pictures available before the rainy season to compare if the damages were increased by lack of maintenance or could have been prevented by additional maintenance.

A summary of the site visit, including pictures and descriptions from all locations can be found in Annex 3.

2.1.1 Pre site visit desktop study

In order to prepare for the site visit, a desktop study was conducted analyzing the available design reports and drawings for the new construction, as well as identifying the expected natural hazards along the entire corridor. As the NETIP corridor is over 700 km long, and the budget available for this project only allowed for a maximum of 10 days of site visits, areas to be investigated were limited to critical assets located in high risk areas. Critical assets are those which have a high cost of construction, and/or are difficult to construct and will result in long durations of disruption. For more information on identifying critical assets and high risk areas, see the guidelines for performing a vulnerability assessment.

Major assets, such as multiple-cell box culverts and bridges where data was available for the new designs, were mapped in GIS. These assets were then overlaid on top of available natural hazard risk maps to identify key areas to be visited. Figure 1 shows the key assets to be visited overlaid on top of available risk maps for the NETIP corridor.

Figure 1 Overview Map showing Key Assets for site visit overlaid on top of flooding, earthquake and landslide risk maps.

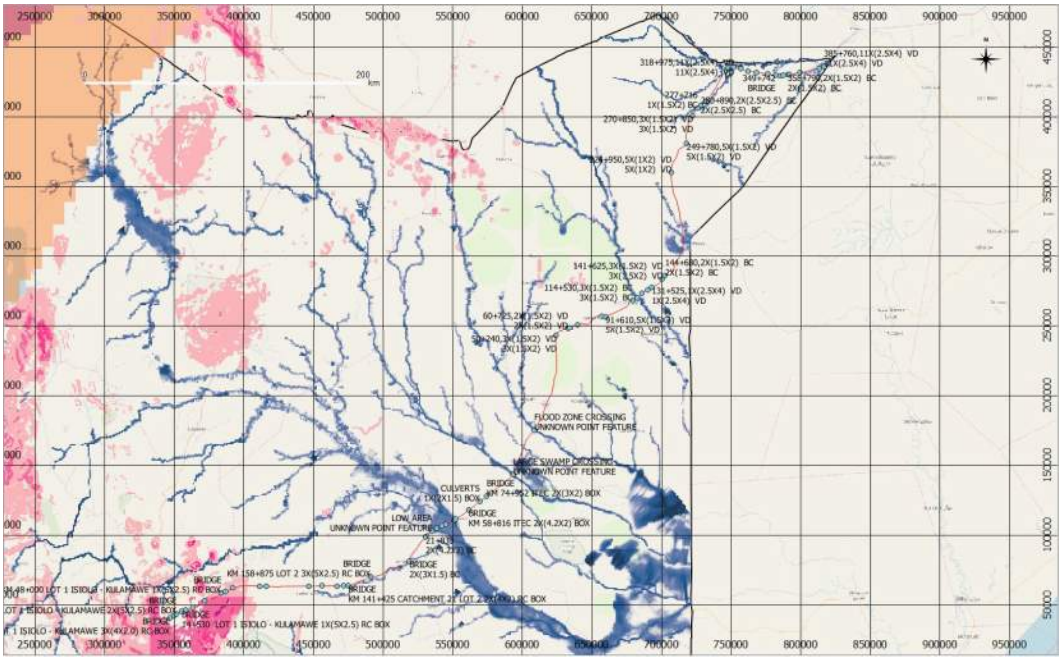
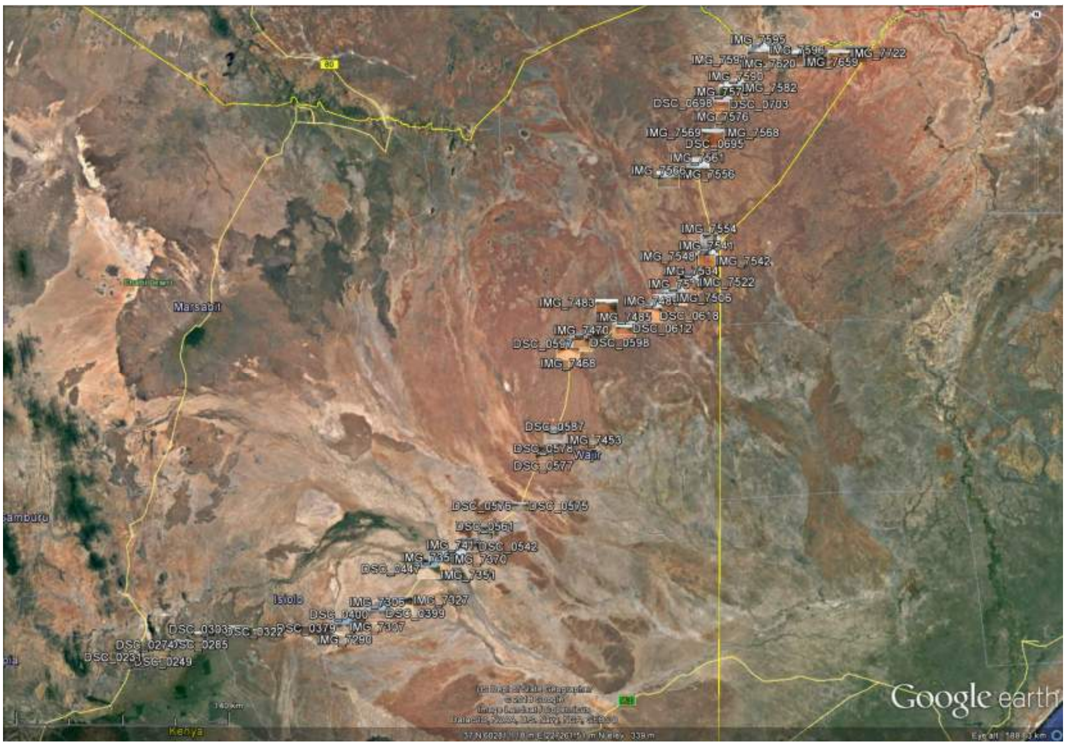


Figure 2 shows the actual locations where the site visits were performed which matches up closely with the desktop study.

Figure 2 Google Earth image showing where site visit photos are taken



2.1.2 Meetings with Regional Maintenance Teams

Before conducting the site visits in detail, Norken Int. met with the maintenance teams of KeNHA in Isiolo and Habaswein to discuss the current road conditions and security situations. Minutes of meetings are included in Annex 3.

2.1.3 Hazards identified

Currently, there are many areas of the NETIP corridor which are damaged and require emergency works to repair the road to a passable condition.

The majority of the damages are caused by flooding. There are also many areas of the road that become impassable due to the difficult soil conditions.

The main hazards noted along the corridor are related to:

Flooding
Washouts
Scour
Erosion
Siltation/Debris
Soil Conditions

The below photos show examples of the hazards identified from the site visit along the corridor.

Flooding

Figure 3 Site visit point 30 Water crossing at the flooded plain with no drainage structure. Coordinates: N0°57'47.38" E39°23'8.07"

Figure 4 Site visit point 48 Flooded section on the rhs of the drift. Coordinates: N1°17'30.76" E39°50'35.88"

Washouts

Figure 5 Site visit point 39, Washed out drift location, with no diversions for vehicles to pass. Coordinates: N0°59'45.76" E39°27'45.93"

Figure 6 Site visit point 82, twin culvert of diameter 900mm eroded by the storm water. Coordinates: N3°55'46.20" E41°16'54.05"

Scour

Figure 7 Site visit point 86, Seriously scoured section of a drift. The scouring is about 2m. Coordinates: N3°54'8.21" E41°23'24.25"

Figure 8 Site visit point 21, Protection works on culvert outlet, undermined by the storm water. Coordinates: N0°37'55.61" E38°55'20.14"

Erosion

Figure 9 Site visit point 72, No drainage structure on the section with both sides of road showing gulley erosion. Coordinates: N3°25'28.22" E40°57'11.34"

Figure 10 Site visit point 66, Side of road section eroded by flood water , a length of about 500m of the road on both sides. Coordinates: N2°36'31.21" E40°50'58.18"

Debris/Siltation

Figure 12 Site visit point 2, 900mm diameter cross culvert, which is Silted. The information obtained from the locals is that the culvert overtops during the wet season. Coordinates: N0°21'53.34" E37°37'35.53"

Figure 11 Site visit point 21, Inlet view on the lhs of the twin box culvert with branches stuck at the culvert. Coordinates: N0°37'55.61" E38°55'20.14"

Soil conditions

Figure 14 Site visit point 24, Sand deposited on the road by rain water flowing along the road during the rainy season. Coordinates: N0°41'32.82" E39°4'19.92"

Figure 13 Site visit point 53, Drift section with difficult soils. Coordinates: N2°15'53.58" E40°15'37.15"

2.1.4 Comparing with Aerial photos

Much of the site visit locations were determined from desktop studies using available satellite imagery from Google Earth. The site visit photos confirm the validity of using the aerial photos in initial identification of vulnerable areas. The satellite photo shown below was taken December 2014, where deterioration of the roadway and development of a bypass road is visible. The photo below at ground level, was taken during the site visit in May 2018 where the damage to the roadway is confirmed. It becomes evident that the problems in this area have either been recurring frequently or never repaired in the last 4 years.

Figure 15 Site visit point 89, extreme scouring along road, with aerial photo taken in 2014 showing damages, and site visit photo taken in 2018

2.1.5 Comparing with Risk Maps

The desktop study utilized risk maps sourced from the World Bank's Climate change knowledge portal in addition to using aerial maps to identify vulnerable areas. The results from the site visits confirm that the areas listed as high risk to flooding in the risk maps are often those which experience the severe impacts.

Figure 16 Site visit point 48, photo on left shows asset located in high flood risk area, photo on right shows flooding next to road from May, 2018

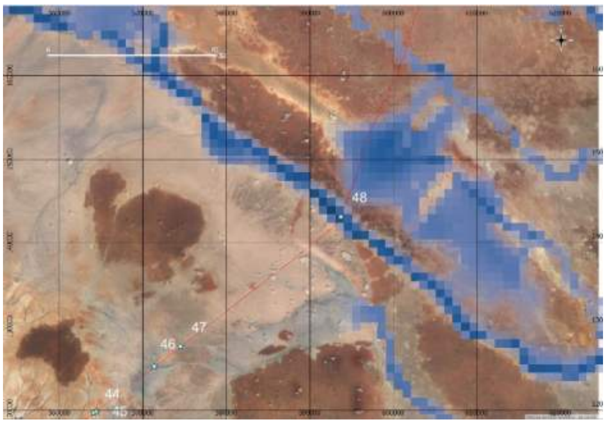
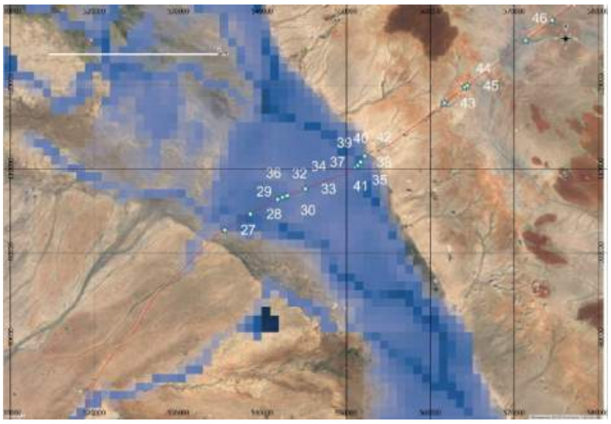


Figure 17 Flood risk map for the Lorian Swamp showing high risk areas for flooding. Evidence of flooding and standing water along Lorian swamp, site visit locations: 29, 38 ,41.



2.2 Climate Change Impacts on Identified Hazards

Climate change forecasts are discussed and summarized in Interim Report 1. These forecasts are showing slight increases in both 24 hour precipitation and temperatures between 2015 and 2090. Figure 18 shows that the median projections for 24 hour rainfall is expected to increase between 3 and 6% between 2015 and 2050 and 2090.

Figure 18 Expected development in median maximum daily rainfall based on 29 GCMs and 4 RCPs for Kenya and the present historical rainfall in Wajir.

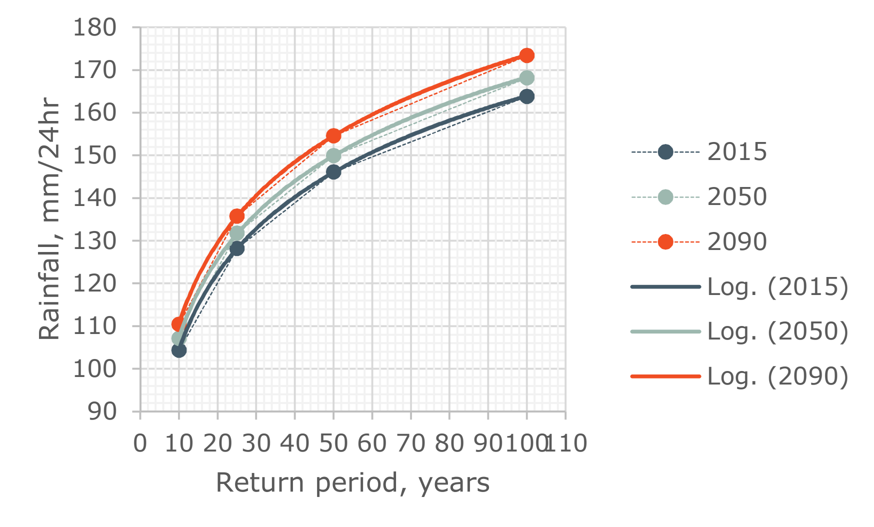


Table 1 Change in maximum in maximum daily maximum temperature per month in year 2050 based on statistical processing of climate change data for Kenya for 29 GCMs and 4 RCPs. Temperature given in degrees Celsius.

Change in max. daily temperature	max.	all 12 month Avr.	min.	Jan	Feb	Mar
Minimum	0.78	0.25	-0.37	0.11	0.30	0.25
10% percentile	1.02	0.81	0.44	0.63	0.82	0.88
Median	1.54	**1.41**	1.12	***1.30***	***1.46***	***1.37***
90% percentile	2.27	2.12	1.83	1.94	2.06	2.15
Maximum	3.14	2.76	2.49	2.49	2.66	2.74

The impacts from these climate changes on the hazards identified from the site visit are summarized below.

Flooding and Washouts

Flooding has been identified at many locations along the corridor. With an increase in precipitation, this may lead to more frequent, extreme flooding in the future. Climate change forecasts are showing relatively small increases in extreme events for this corridor. It is expected that areas prone to flooding now will continue to be prone to flooding in the future.

As with flooding, an increase in precipitation may lead to an increase in flooded streams which can result in washouts. The median predictions are showing an increase in 24 hour rainfall of 3-6% between 2050 and 2090, which correlates to the return intervals as shown below:

Table 2 *Change in return period (years) for present design storms at Wajir.*

2015	2050	2090
10	9,0	8,0
25	22,0	19,1
50	43,3	36,7
100	84,6	70,2

By 2050, a 100 year return interval storm is expected to occur on average every 84,6 years. Climate change may have a negative impact on the capacity for some of the larger drainage structures whose lifespans will reach into 2050 and beyond, including many of the box culverts and bridges.

Scour and Erosion

The depth of Scour is affected by soil conditions and water velocities. Increases in precipitation may increase water velocities, which could intensify the effects of scour. More detailed scour calculations would be necessary to predict the actual increases in scour.

Erosion is similar to scour in that it is highly dependent on the soil conditions. Increases in temperature may lead to increased drying of soils and increased drought conditions. Dry soils subjected to excessive rainfall may be more prone to erosion.

Siltation/Debris

Siltation is linked to erosion of upstream areas, and similar to erosion, siltation and debris may be increased by increases in temperatures and precipitation. Debris clogging of drainage structures can also be increased by increases in drought leading to dying off of vegetation, which is then washed downstream by increased flows.

Soil Conditions

Soil conditions can be negatively impacted by increases in precipitation and increases in temperature. Increases in temperature can lead to increased droughts, which may lead to large variations in the soil conditions, which can in turn lead to cracking of the pavement surfaces.These same soils can also be impacted by increased flooding and moisture, leading to expansion of the soil and cracking and heaving of the road surface.

3 Design review and Priority Interventions

3.1 Introduction

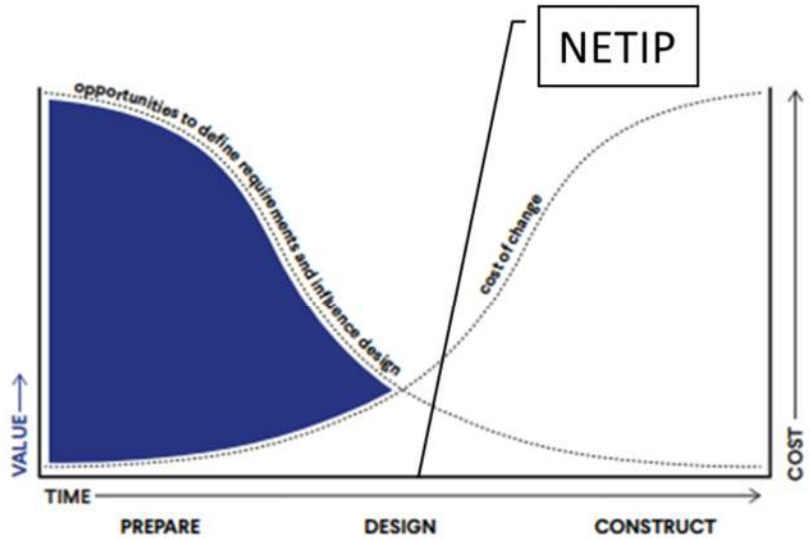
Draft Final designs from 2018 have been provided for the NETIP corridors between Isiolo and Samatar Road. Designs from 2010 were provided for the sections between Wajir and Mandera, however, these designs are in the process of being updated to 2018 standards. Designs for the section between Samatar Road and Wajir have not been provided.

The designs have been reviewed from a climate resilience perspective for the sections between Isiolo and Samatar Road. The designs have been studied from the perspective of looking at how additional extreme events and raising temperatures may impact the project.

The process for the design review entailed reading through the design reports and drawings available. Where possible these designs were imported into GIS and overlaid the available risk maps and aerial photos to determine locations where vulnerabilities are highest.

As the timing for the design review is quite late in the process, we have focused on areas where smaller changes to the design will have the greatest benefit. Figure 19 shows an example of where the cost of changes to the design will result in the most benefit and value for the project.

Figure 19 Design Process, Cost vs Value over time



Opportunity to increase value *[source: CABE, Creating Excellent Buildings: A Guide for Clients, 2003]*

The NETIP corridor sections reviewed are in the final stages of Final Design and will soon be sent out for Tender and construction. Any major changes suggested at this phase are likely to result in large increases in cost and time for redesign. Therefore, we are proposing design improvements as well as monitoring and maintenance rather than complete changes to the alignment or drainage elements.

3.2 Priority Interventions

Due to the isolation of the NETIP corridor and the current security situation, routine maintenance may prove to be difficult. This will most likely be true for emergency response maintenance and repairs as well. It is therefore recommended to construct a new roadway as robust as economically feasible. One of the goals of the NETIP corridor is to increase the connectivity of the region to the rest of Kenya. The proposed designs provide a good starting point for this, but after construction, the success of the road will be dependent on proper maintenance and emergency responses.

By reflecting on the damages to Kenyan roads from the extreme rainfall events in 2018, it is expected that there will be incidents along the proposed corridor NETIP which could cause temporary disruptions. These cannot be foreseen and adequately designed for with the available budgets. The duration of these disruptions will be dependent on the response plans set in place by KeNHA.

Priority interventions have been identified based on a design review and site visits. In the following pages, examples are given that describe methods to increase the robustness and resilience of the road and help counteract additional climate change impacts. The suggested interventions are described using exact locations along the corridor, however, the methodology should be implemented in other locations that could benefit from increased robustness. For example, Intervention 1, which describes increased bank protection for the wide floodplain at Point 2 of the site visit, is relevant for multiple locations along the corridor; however, only one location has been identified for this study. The following interventions utilize relatively low-cost methods and materials that are already being proposed by the engineering designs. Actual costs for interventions and maintenance can be generated on a case-by-case basis, as necessary.

The priority interventions for NETIP include:

1. Increase Bank Protection for wide floodplains
2. Bank Protection at Bridges
3. Road Overtopping Protection
4. Reduce Sedimentation Rates from Sand
5. Decrease Roadside Erosion
6. Strengthen Lorian Swamp Embankments
7. Maintenance Depots and Emergency Response Plans
8. Data Collection

Intervention:	Increase Bank Protection for wide floodplains	**No**	*1*
Objective:	Decrease scour and erosion at embankment footing at wide floodplains.		

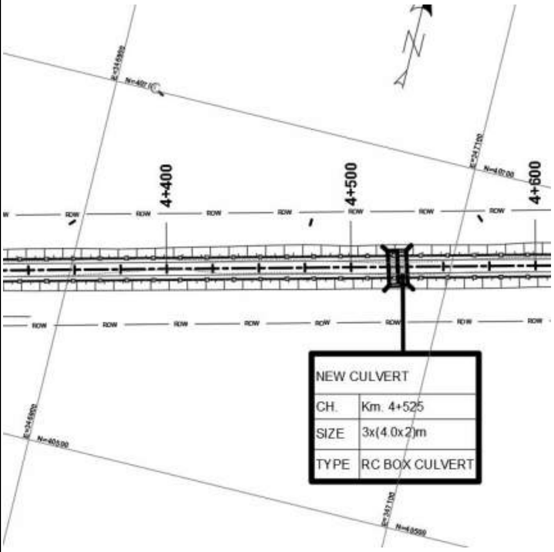
Context:
One new large culvert is replacing 3 small culverts over a distance of 200 m, but is not placed at the center of existing channel. Channel location likely changes over time and may not be stable. This area currently experiences flooding along the wide floodplain, and some of the existing culverts are experiencing washouts due to being undersized for current rainfall amounts. Proposed Right of Way is relatively narrow, and it may not be possible to implement sufficient river training to direct all flow towards single culvert. Flood waters will most likely intersect new roadway embankment at 90 degree angle and run parallel to footing of roadway embankment until it reaches culvert, resulting in excessive erosion if the bank is not properly stabilized.

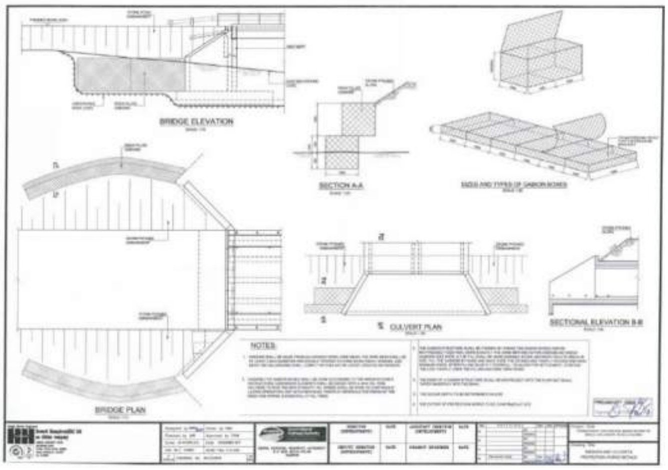
Climate Change influence :	Increase in extreme events, increased flooding

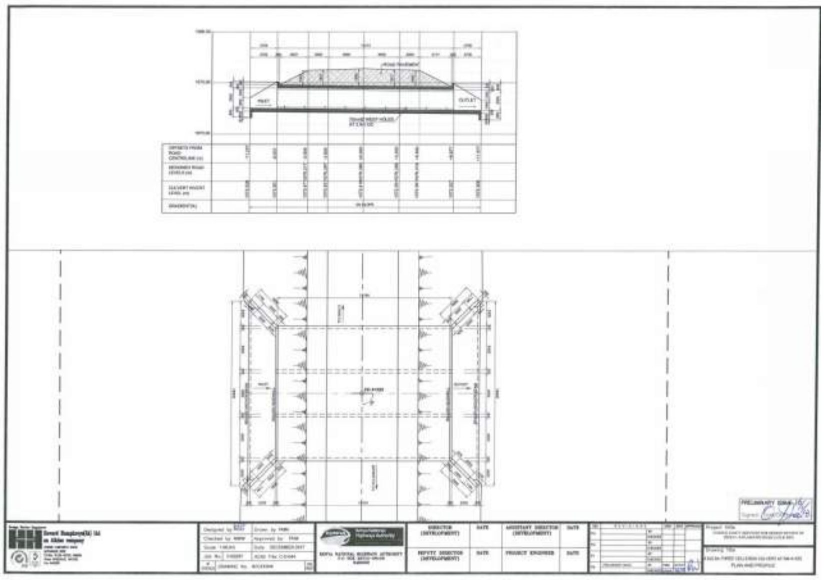
Location :
Point 2(Site Visit) Coordinates: N0°21'53.03" E37°37'34.31"
This issue is found along many of the wider flat floodplains, where there is one large culvert that replaces a series of smaller culverts and has been sized to accommodate the design storm for the entire upstream catchment area. This case study example is at chainage 4+500 between Isiolo and Kulamawe.

Proposed design by consultant:

Typical culvert details show only a short section of gabion bank protection, and the plan drawing for this culvert does not show any additional bank protection or river training. Plan drawings state that “Protection works for embankment and fill material to be as shown on drawings or may be altered to suit site conditions.”







Possible damages:

Erosion that is not repaired quickly could result in undermining of the roadway embankment resulting in partial failure of the embankment and possibly sections of the road. In this location, it is expected that damages could result in up to 250 m of embankment erosion.

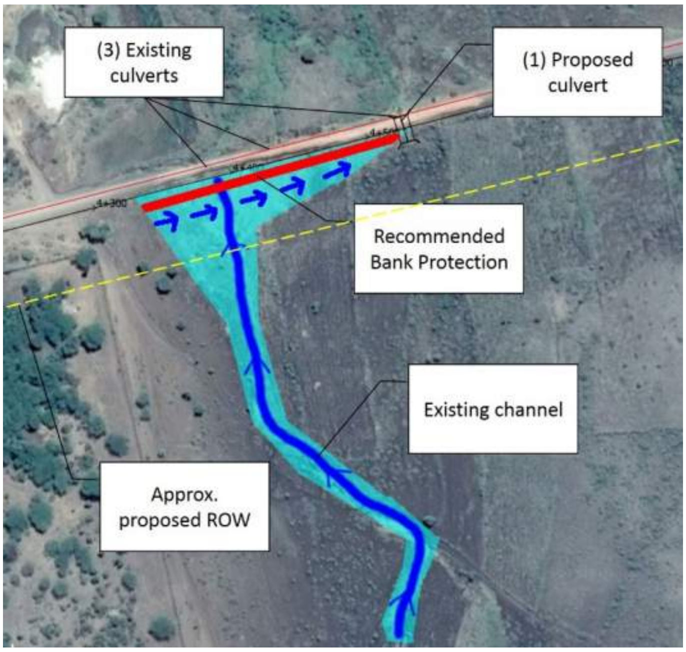
The likelihood of these damages occurring is dependent of the severity of the storm and the erosive properties of the soil. Test pits in this location show poor soil conditions with a mix of silt, sand and black cotton soils which can be erosive.

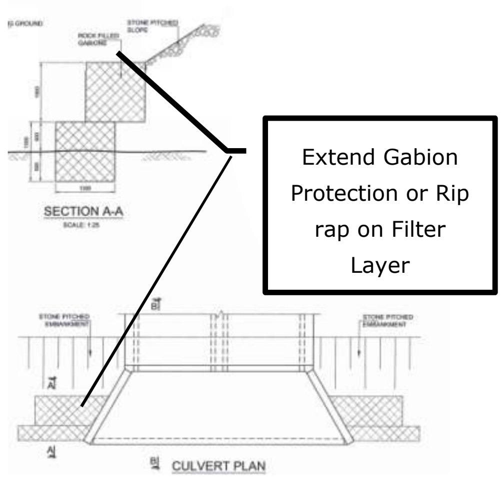
Km 3+000 LHS - PIT NO. 4		Km 4+000 RHS - PIT NO. 5:		Km 5+000 LHS - PIT NO. 6:	
350mm	BROWNISH SILT SOIL	300mm	BROWNISH SILT SOIL	250mm	CLAY SILT SOIL
1200mm	GREY BROWNISH SANDY GRAVEL	1300mm	BROWN SILT GRAVEL WITH TRACES OF BLACK COTTON	1300mm	SILT SANDY SOIL WITH BLACK COTTON SOIL
GPS CO-ORDINATES :	$00^{0}2143.2$ $037^{0}3653.6$	GPS CO-ORDINATES :	$00^{0}2150.0$ $037^{0}3725.7$	GPS CO-ORDINATES :	$00^{0}2159.2$ $037^{0}3756.5$
ELEVATION:	1084M	ELEVATION:	1080M	ELEVATION:	1086M
NOTE:	Km 0+000 - Km 5+000 - The section seems to have poor soils of either brownish silt soil or black cotton soil				

If a very intense storm occurs, the erosion could occur within a short time period, however, even with 1 or 2 year design storms, there is still expected to be erosion if there are no protection measures, which over a longer duration with limited maintenance could still result in embankment failure.

Damage costs from erosion is dependent on the severity of the storm. For smaller storms, there will be an increase in maintenance resulting in reshaping and compaction of the embankment. For larger storms, which result in embankment failure, there could be need for partial road reconstruction. For this section, it is expected that a 50 year storm will cause major damage to the embankment resulting in partial reconstruction of the embankment and paved road surfaces.

Recommendations:
Without a detailed site survey of the existing channel, it is difficult to assess the accuracy of the proposed culvert location. From satellite photos, it appears that the culvert is not placed at the center of the existing channel, but there is likelihood that the channel can move in the future. With a detailed survey and clearer knowledge of the stability of the channel, it could be recommended to move the culvert to a new location. However, when faced with limited data and high uncertainty, moving the culvert may not reduce the possible erosion problems if the channel moves in the future. Therefore, it is recommended to place 250 m of gabions or stone pitching bank protection to decrease scour and erosion along embankment where water travels parallel with new embankment prior to crossing under new culvert. There is a likelihood that the quantities for bank protection necessary in this area are underestimated, and due to the extra cost and time to install additional bank protection, they may be left out if not required by the site inspector during construction.





CDOT Drainage Design Manual *Bank Protection*

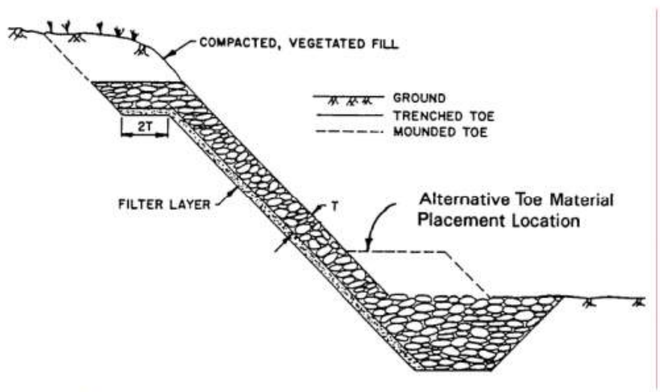


Figure 17.13 Typical Riprap Installation: End View (Bank Protection Only)

Intervention:	Bank Protection at Bridges	**No**	*2*
Objective:	Prevent upstream erosion and scour at embankments near bridges		
Context:			
A new 25 m wide bridge is being placed downstream of existing. Area is showing large amounts of scour in existing channel and embankments.			
Climate Change influence :	Increase in extreme events, increased flooding		

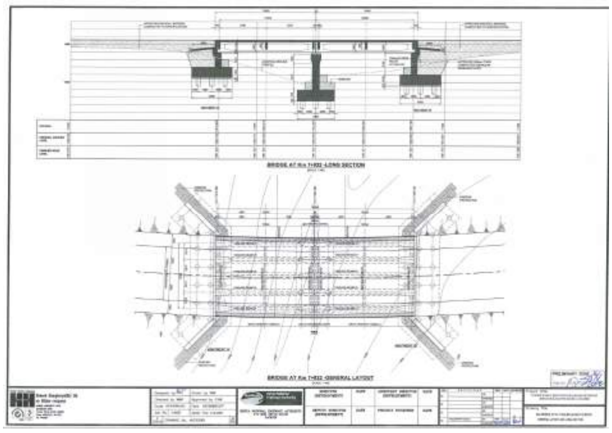
Location :

Site Visit Point 3 Coordinates: N0°22'41.72" E37°39'8.72"

There are very few bridges along the NETIP corridor. This case study example is located near chainage 7+932 between Isiolo and Kulawame.

Proposed design by consultant:

The consultant has proposed bridge embankments and footings on piles to prevent against the expected scour. Footings and embankments are further protected by gabion baskets.



Possible damages:

As seen on other sections of the NETIP corridor. Gabion protection can be undermined if not constructed for a large enough area, or subject to very high velocities. The purpose of the gabions is to protect the footings and the embankments from damage due to scour, and if they do not serve their purpose, the bridge could be damaged requiring repairs to the concrete works.

Recommendations:

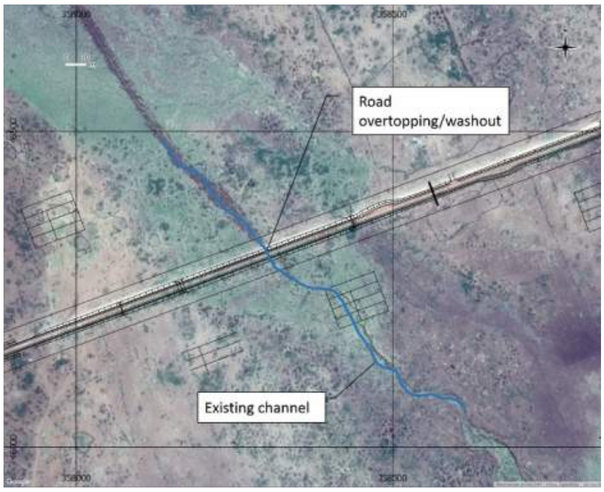
The proposed bank and bridge pier protection should be monitored frequently to assess if there are shortcomings. It is recommended to monitor the upstream and downstream embankment before, during and after rainy seasons, with replacement or installation of additional gabion baskets, if necessary. If the existing bridge is removed, river training and additional embankment protection may be required, as the existing bridge is most likely channeling the flow to its current location. Without the existing bridge, there may be a wider area susceptible to erosion.

Intervention:	Road Overtopping Protection	**No**	*3*
Objective:	Reduce erosion from flood waters overtopping roads		

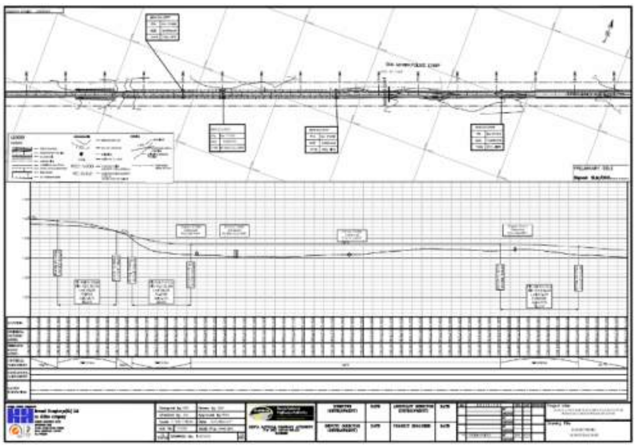
Context:
The existing corridor experiences in many areas flooding which results in excessive erosion to the road caused by the floodwaters overtopping the road. This is experienced most frequently in areas where there are not currently located drainage structures.

Climate Change influence :	Increase in extreme events, increased flooding

Location :
Site Visit Point 6 N0°24'57.25" E37°43'37.01"
This case study location is near chainage 17+400 between Isiolo and Kulamawe.



Proposed design by consultant:



At this location, the consultant has proposed to raise the roadway approximately 3 m for the length of the flood plain, and install 3 additional culverts in the area including two 900 mm pipe culverts and a 3 cell 4x2 m box culvert. This will give an approximate capacity of 60 cms, which should accommodate the projected 50 year storm with a factor of safety of 1.23. The roadway and shoulders are planned to be paved which will also help to reduce erosion.

Possible damages:

With the flows calculated by the consultant, the suggested culvert sizing and the raised roadway should prevent flood overtopping in this area. Potential damages could be expected from erosion and scour. The proposed large box culvert does not appear to be placed in the natural stream channel, according to aerial photo observations, and therefore monitoring and/or additional bank protection may be necessary to protect the embankments from erosion.

In areas that experience overtopping from flood waters, Schneider and Wilson (1980) have estimated that paved areas prone to an overtopping depth of 1 m could experience upwards of 50% of pavement loss and 40% of embankment loss if covered for a duration of 40 hours.

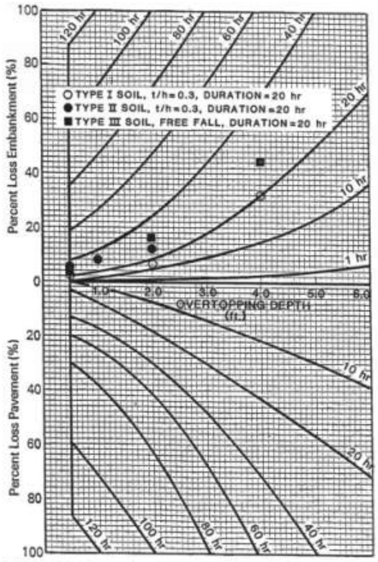
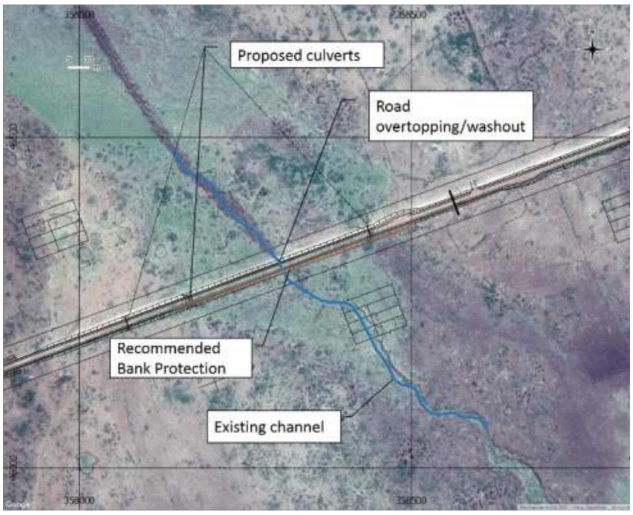


FIGURE 98 Embankment pavement losses (after Schneider and Wilson 1980).

Recommendations:



Where there is risk of flood waters encroaching on embankments, additional embankment protection is recommended. The type of embankment protection is dependent on local climate and the expected velocities of the flood waters impacting the embankment. In this area, there appears to be existing vegetation, which may mean that it is possible to reinforce the embankments with seeding and planned vegetation without needing to supply additional irrigation.

It is recommended to calculate flow velocities in more detail in order to predict the magnitude of erosion in this area and to reinforce the embankments with stone pitching, gabion walls or vegetation, if it is deemed that vegetation will grow well without additional irrigation.

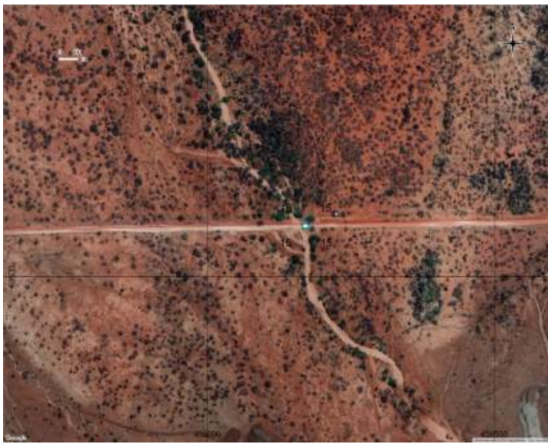
Intervention:	Reduce Sedimentation Rates from Sand	**No**	*4*
Objective:	Ensure culverts are free of sedimentation to ensure design capacity		

Context:
There are sections of the corridor that pass through areas with large amounts of exposed sandy soil. These areas have high sedimentation rates in the existing culverts, which reduces the capacity of the culvert and can increase the vulnerability to flooding. Sand is often found on stretches of the roadway.

Climate Change influence :	Higher temperatures could increase droughts, which can increase the amount of exposed, loose, dry sediments. Increase in extreme rainfall and increased flooding may result in movement of greater amounts of sedimentation.

Location : Site visit Points 15,18 N0°34'21.24" E38°36'25.15", N0°34'17.64" E38°46'36.97"

Sandy areas are found in many sections of the corridor East of Kulamawe. The first photo shows a drift with sandy stream near chainage 122+000 on Lot 2, and the silted culvert is near chainage 140+900.



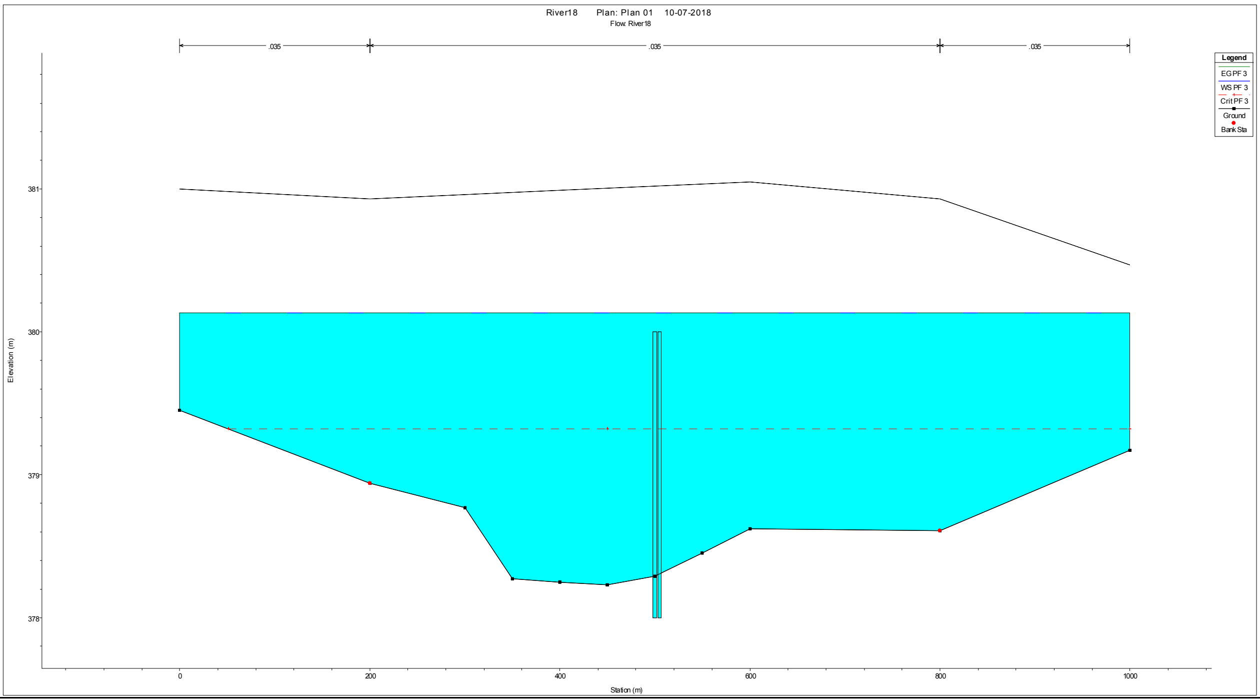
Proposed design by consultant:
Near chainage 122+000, the consultant proposes to lift the roadway 2.7 m above the existing terrain and add a 4 x 2 m box culvert. Near 141+400, the consultant proposes to lift the roadway 2.8 m and place a 2 cell 4 x 2 m culvert.

There appears to be no special provisions to avoid excessive sedimentation in the design reports, other than culverts shall have a minimum gradient to promote self cleaning.

For the culvert at 121+825, the projected design flow for a 25 year storm is 15.06 cms, the capacity of the projected culvert is 19.23 cms, giving a factor of safety of 1.28. If there is more than 30 cm of sedimentation or blockage in the culvert, there will not be capacity in the culvert for a 25 year storm.

For the culvert at 141+425, the projected design flow for a 25 year storm is 33.03 cms, the capacity of the projected culvert is 38.47 cms, giving a factor of safety of 1.28. If there is more than 18 cm of blockage in the culvert, there will not be capacity in the culvert for a 25 year storm.

Possible damages:
Because the floodplains are wide and the roadway has been raised over 2 m, it is unlikely that there will be overtopping in this area. It is more likely that will be standing water along the embankment after storm events until the excess water discharges through the culverts. An example is seen in the below HEC-RAS model from the culvert at 141+425, based on the existing terrain from the vertical profile drawings. Since the floodplain is so broad, a 25 year storm could generate standing water along a 1000 m section of roadway while it waits to discharge through the culvert. Though the duration of the standing water is not long, significant amounts of sediment can be deposited. Similarly, because of the wide floodplain, the velocities through the culvert may not be as high as expected, and self-cleaning of the culverts may not be as efficient as planned, which may require additional maintenance activities.



Recommendations:
For areas that experience high rates of siltation from sand, it is recommended that maintenance activities be increased to ensure that culverts are free of debris. It is recommended to log the siltation properties over time to determine if the problem is becoming worse. It may be necessary to add siltation basins upstream of the culvert if the siltation loading becomes too high to ensure clear culverts.

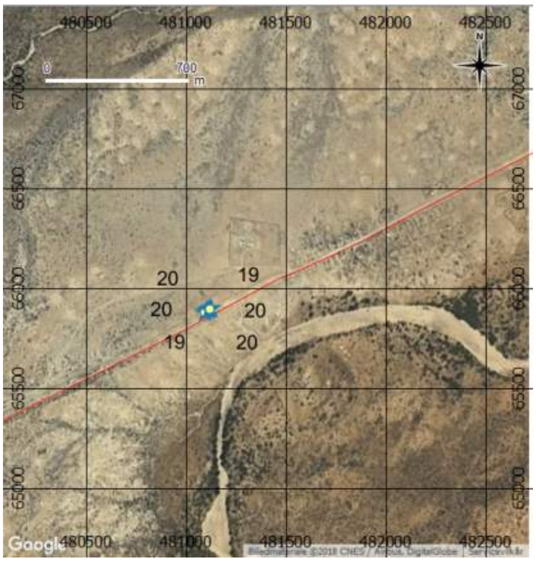
Intervention:	Roadside Erosion	**No**	*5*
Objective:	Increase roadside protections to reduce scouring		

Context:
Existing road is susceptible to roadside erosion from water flowing along roadway.

Climate Change influence :	Increase in extreme events, increased flooding

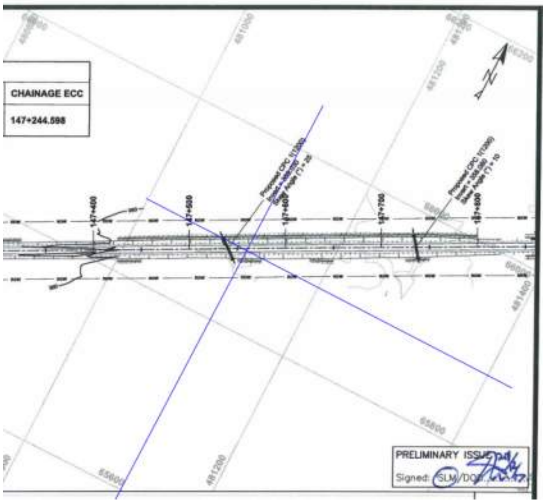
Location : Site Visit Point 19 N0°35'36.48" E38°49'52.43"

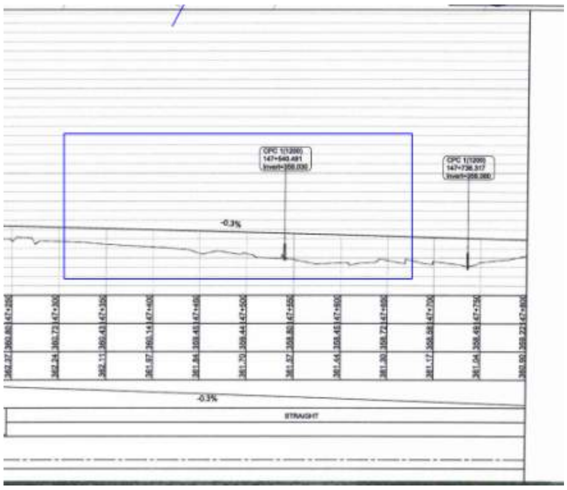
These photos are taken near chainage 147+500, where the existing terrain is relatively flat. In flood situations, water may be flowing from the main channel and eroding the existing road. The erosion is occuring where flood waters are entering an existing culvert.



Proposed design by consultant:

A new culvert is proposed in the area where the photos are taken. Where there is a culvert, the alignment is between 2.5 and 3 m above the existing terrain. There are currently no additional embankment reinforcement provisions in this area.





Possible damages:

As there is already evidence of existing scour in this location, it is likely that there will be scouring to embankments if protection is not added. The existing terrain is not very steep, but there is evidence of high velocities from the pictures of scouring. Damage is expected from scouring of embankments leading to possible embankment failure and damages to pavements.

Recommendations:

It is recommended to survey this area in more detail to determine where the flooding is coming from to determine the most relevant design intervention. Without further investigations, it is recommended to add additional bank protection here using either stone pitching or gabions. See Interventions 1-3 for examples.

Intervention:	Strengthen Lorian Swamp Embankments	**No**	*6*
Objective:	Increase protection of embankments to reduce damages from standing water and concentrated flood flows		
Context: The proposed highway passes through nearly 25 km of flat area collectively known as the Lorian Swamp. This area is prone to frequent washouts, flooding, and standing water. The proposed road will be raised on average 2.7 m above existing terrain which may eliminate or reduce flooding over the roadway, but may cause a damming effect for upstream flows. If water cannot pass the roadway sufficiently, the duration of standing water alongside or over the road is increased. Seepage through embankments, as well as rapid drawdown is a common cause of roadway embankment failures.			
Climate Change influence:	Increase in extreme rainfall events, increased flooding		
Location: As a result of the rainy season, standing water has been observed many areas along the highway section through the Lorian swamp. The flooded areas observed are concentrated between chainage 31+000 and 39+000, and between 44+000 and 48+000. The pictures below are taken at Site Visit Locations 29, 32 – 41. These areas of standing water correlate well with the greenest areas shown in the aeriel photo of the Lorian Swamp below, which most likely mean that large volumes of water resulting in vegetative growth. The browner areas are most likely more arid and more prone to seasonal flooding with limited standing water. Standing water is observed near areas where existing drainage elements are undersized as well as areas where existing drifts have been washed out due to recent flooding.			

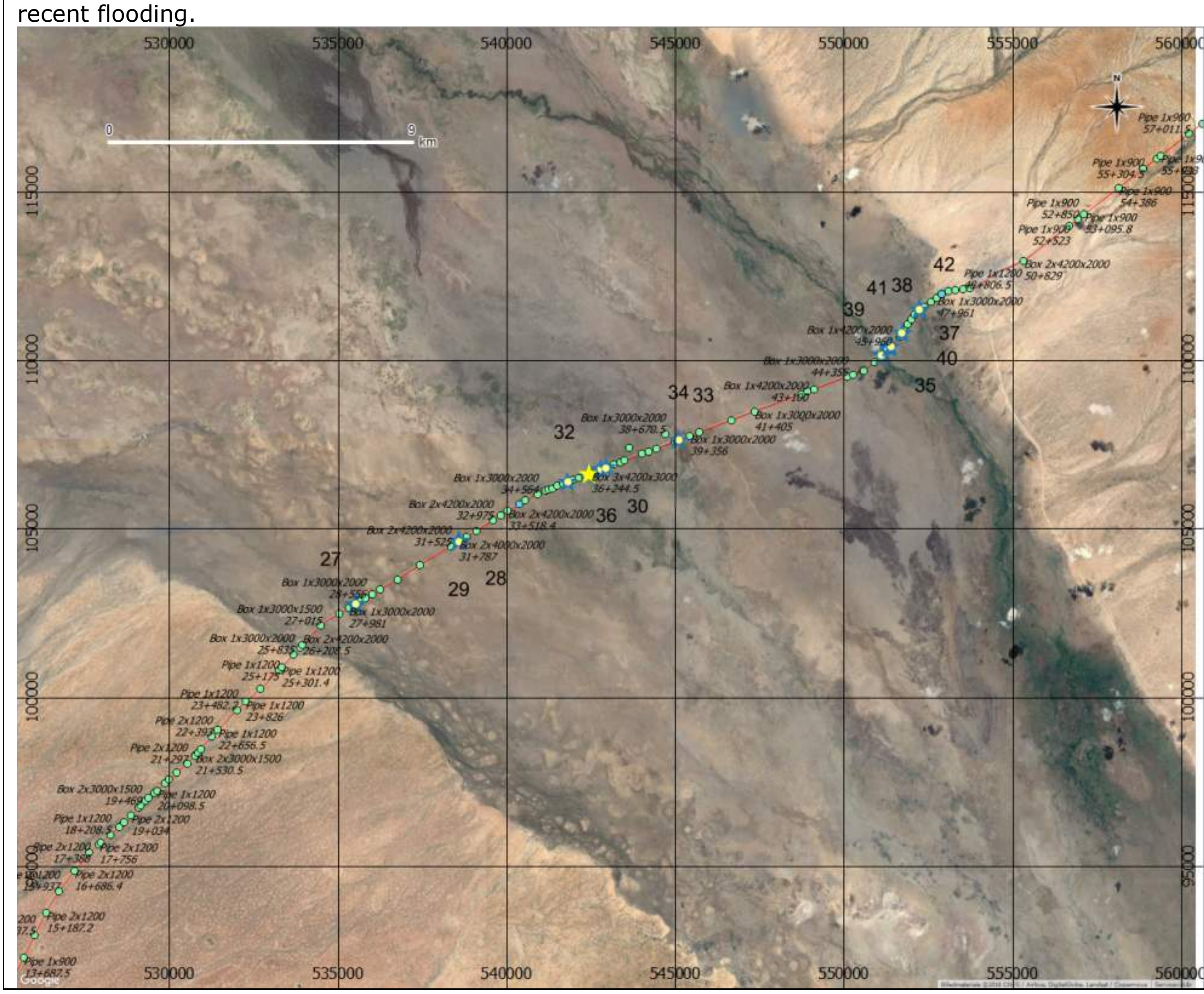


Figure 21 Flooded plain with no drainage

Figure 22 Washed out drift and flooded plain

Proposed design by consultant:

The highway section through the Lorian Swamp (26+200 -48+000) is lifted on average 2.7 m above existing terrain, with a maximum embankment height of 5.0 m and a minimum embankment height of 1.3 m.

For the embankment through the Lorian Swamp, the consultant proposes the following design, as described in the design report.

The section between Km 26+200 to Km 48+000 has been identified as flood prone and the embankment in this section shall require special treatment to withstand the effect of the flooding. The following measures have been proposed:

1. Provision of sufficient cross drainage structures to allow passage of water across the embankment fill.
2. It is proposed that in this section the embankment be of such height as to ensure that the bottom of subgrade remains at least 1.0m above the highest water table/ flood water level (IRC:SP:73 – 2015)
3. Fill material that meets the criterion for subgrade materials used in this road shall apply for this specific flood prone section. Layers of 150mm shall be used and compacted to the MDD and OMC of the subgrade.
4. At critical locations where the ground treatment is required as per the site condition especially in the swampy area the ground shall be stabilised with rock fill. According to Clause 507 of The Standard Specifications for Road and Bridge Construction, the maximum dimension of rock fill shall be 250

mm, reasonably well graded and with less than or equal to 5% finer than 10mm material. Each layer will be blinded with smaller rock fragments so as to fill as many of the voids as possible before the next layer is placed. A filter fabric (geo-textile) will then be placed around the rock fill before placing the earth fill material.

Side Slopes are proposed as:

7.11 SIDE SLOPES

As per the design standards for slopes

The fill slopes proposed are as follows

Up to Height	Fill slope (V: H)
0 to 1m	1:4
1 to 3 m	1:2
>3m	1:1.5 with Guard rail

In some places, the natural channels run parallel and adjacent to the project road. In such stretches, the road embankment requires protection from erosive forces of running channels. Such protections shall be in addition to the nominal protections near bridge and culvert wings/Abutments. The protections shall be with dry stone pitching. Embankment protections along the Lorian swamp are proposed at:

Chainage		Side (Increasing Chainage), Left /Right / Both	Length of Protection (m)
From	To		
26+200	26+300	Left	100
27+600	33+000	Left	5400
33+400	33+550	Left	150
36+900	39+000	Left	2100
40+300	42+100	Left	1800
43+150	43+700	Left	550
45+200	47+600	Left	2400
48+300	48+600	Both	600

Culvert and bridge capacity has been designed to accommodate a collective 100 year storm in the Lorian Swamp. The discharging capacity of the proposed new bridge at Habaswein has been estimated as 212 cumec. Thus the discharge to be carried by the group of culverts between Km 26 and Km 48 comes to be (1685 – 212) = 1473 cumecs. Location of Culverts has been primarily decided on the basis of site visit observations and existing road profile surveyed.

Possible damages:
From NCHRP 2016, Common failure modes to roadway embankments include:

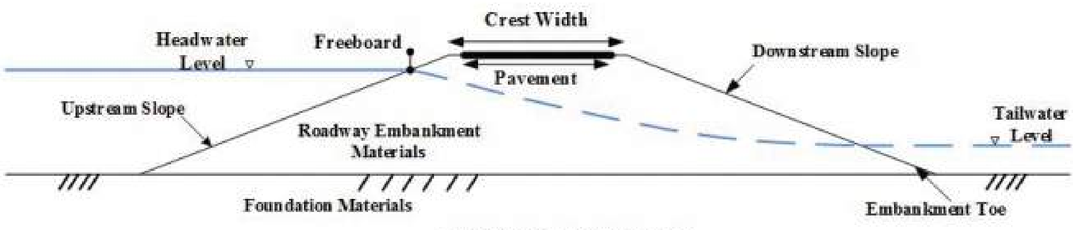
1. Overtopping erosion
2. Softening by saturation
3. Underseepage and piping
4. Through-seepage (internal erosion) and piping

5. Wave erosion
6. Lateral sliding on foundations
7. Other failure modes including culvert failures and pavement failures.

Possible failures expected along the Lorian Swamp include damages from 1,2,3,4,and 7.

Due to the highway being lifted and the additional installation of culverts being installed, overtopping is not expected to be a major cause of damage. Damages are expected to come from softening by saturation and seepage, and possible culvert failures if scouring or floods are larger than designed for, if culverts become clogged with sediment or debris, or there is prolonged standing water near the embankments.

Figure 23 Source: Minimizing Roadway Embankment Damage from Flooding



(a) Riverine Environment

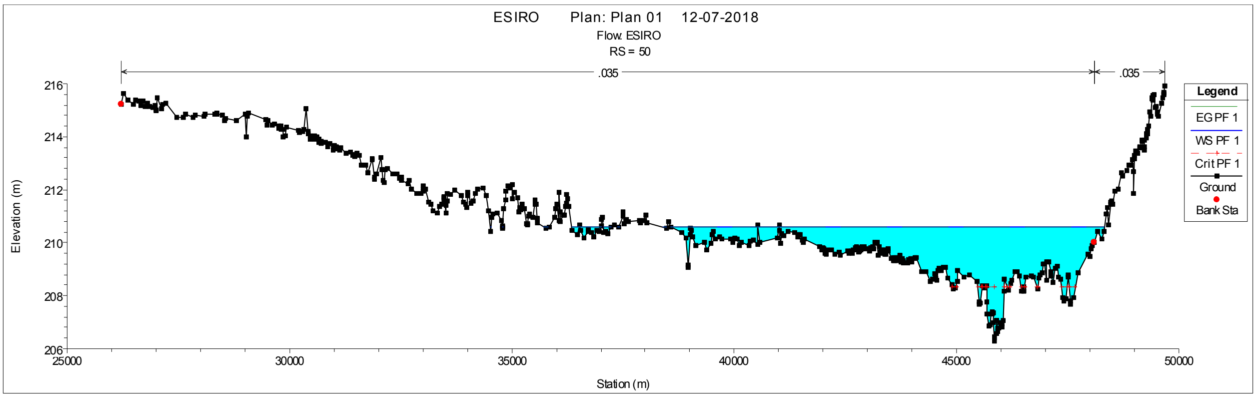
Damages from softening by saturation is caused by the upstream floodwaters receding faster than the embankment materials can drain which can result in potential instability underneath the roadway. This can lead to pavement and embankment failures. Seepage through the embankment can also lead to an overly saturated embankment on the downstream side which can lead to embankment failures.

Figure 24 Source: Minimizing Roadway Embankment Damage from Flooding

FIGURE 83 Homogeneous embankment section on impervious foundations with emerging seepage on the landside slope (after USACE 2000).

Recommendations: The design for the embankments proposes that the roadway subgrade be placed a minimum of 1 m above flood waters. However, when the terrain through the Lorian Swamp area is analyzed, there is an elevation difference of approximately 9m. The elevation is 215 m at the beginning of the Lorian Swamp on the west side, and 206 m for the lowest point. Without 2D flow modeling, it may be difficult to accurately predict where the high water mark will be after the construction of the new embankments.

Figure 25 HEC-RAS with existing terrain and 1685 CMS



By lifting the embankment so high for so many kilometers, it is unknown how exactly the upstream water will be affected, and where exactly the flood waters will flow. The Lorian Swamp includes a series of channels spread out through the 26 km. It may be correct that the water is spread out somewhat evenly over the 26 km as the consultant suggests, however, the worst flooding from this rainy season has been around kilometers 44 – 47 where multiple drifts have been washed out. It is recommended to apply 2D modelling on the swamp area to assess where the expected flood waters will be most concentrated and to check the culvert design assumptions. Given the time available, this may not be possible for this project, therefore it is recommended to monitor the performance of this section and perform frequent maintenance activities.

It is recommended that for areas where standing water is most likely along the embankment, the fill slopes of the embankments be reduced from 1:2 to 1:3. Research shows that shallower slopes are less prone to erosion from standing water.

It is recommended that additional embankment protection be used for areas where standing water is expected to reduce erosion. For areas where vegetative growth is currently observed, it may be suitable to add additional seeding and vegetative protection to the embankments. For areas where vegetation is unsuitable, such as areas where additional irrigation would be necessary to ensure that vegetation is successful, it is recommended to use riprap, stone pitching or gabion boxes.

Intervention:	Maintenance Depots and Emergency Response Plans	**No**	*7*
Objective:	Locate emergency response centers near the most vulnerable locations		

Proposed design by consultant:
There is no mention of proposed maintenance depots or emergency response plans in the design reports received.

Recommendations:
Due to the isolation of the NETIP corridor, it is suggested to have an emergency response plan in place that will account for any critical incidents that have the potential to result in disruption or closure of the roadway. Part of this emergency response plan should result in temporary diversions to maintain connectivity until the original asset can be repaired.

In order to ensure that emergency repairs can be performed quickly, it is recommended that necessary materials are stored in areas near the most vulnerable locations in order to maintain connectivity along the corridor.

It is suggested to place at a minimum two secured maintenance depots where emergency response material is stored.

The first depot is recommended to be placed near the Lorian Swamp, as this area is deemed the most vulnerable to flooding along the corridor. It is recommended to place the depot near Mado Gashi on the western side of the Lorian Swamp rather than in Habaswein on the eastern side. This is due to more secure access from Nairobi and the more populated areas of Kenya. If there is an incident which results in a closure to the road in the swamp area, access to Mado Gashi will still most likely be accessible from the west.

The stockpiled materials to be kept in the depot should be of sufficient quantity and type that a washed out multiple-cell box culvert could be crossed within a short time duration. Bailey bridges are used around the world as temporary bridge passages due to their relatively short time to install. For areas within the Lorian swamp that are susceptible to flooding, it may not be possible to cross a washed out or flooded asset while there is standing water. Alternative diversion methods could be investigated included use of floating bridges as temporary passages.

The second depot is recommended to be placed near the town of Mandera in the north eastern part of the corridor. The existing roads in this area have experienced substantial damage in the past year from flooding and this area is deemed vulnerable to future damage. In the event of widespread flooding along the entire NETIP corridor, it may not be possible for transport to reach Mandera from Nairobi or Mombasa, and it is therefore recommended to ensure that a depot is always stocked with sufficient material to ensure connectivity in this section of the highway.

It is also recommended that the consultants, as part of their engineering design, prepare emergency response plans for how the vulnerable assets could be crossed in the event of a disruption.

Intervention:	Data Collection	**No**	*8*
Objective:	Develop plan for additional collection of climate and maintenance data regarding rainfall, hydrology, and incidents to increase resilience of the roadway network against climate factors.		
Proposed design by consultant: There is no mention of proposed data collection in the reports or data received.			
Recommendations: It is recommended that the NETIP corridor be an example for data collection relevant to road design and maintenance in Kenya. It is recommended that a systematic method for collecting data regarding rainfall, stream flows, and incidents be installed along with the new road construction. The data collection may need to be coordinated with the relevant ministries. It may be possible to install automatic rainfall measurements connected with the new fiber optics cable installed along the corridor to increase the quality of the rainfall data. It is recommended to install stream flow gauges that can be recorded for some of the water crossings. This data can be used to increase the rainfall runoff predictions, and to test the accuracy of the existing runoff formulas used in the EAFM and SCS method for this region. It is recommended that all incidents caused by natural hazards which result in delays are investigated to find the cause, and results are shared with other consultants so that future designs can learn from these lessons. Depending on the transparency desired by KeNHA, natural hazard incidents can also be posted on KeNHA's website so that the public users can follow and learn from the challenges faced.			

4 Mainstreaming climate resilience approaches in road network management and capacity building of KeNHA

4.1.1 Objectives

The objectives of task 5 is to develop recommendations and an action plan for mainstreaming climate resilience approaches in road network management in Kenya and capacity building of KeNHA. This builds on a secondary objective: review of current practices including the institutional and operational set-up in relation to climate resilience.

4.1.2 Methodology

The steps in the approach comprise three activities. Firstly, the existing road management and institutional capacity is reviewed along with the existing institutional and operational set-up in relation to climate resilience. The review of the current capacity of KeNHA is based on available written material and interviews with Kenyan stakeholders. This covers the six following areas:

1. Monitoring and observation of road assets
2. Adequacy of road network
3. Investment Decision Making Framework
4. Asset Life Cycle Strategy
5. Financing
6. Institutional and legal reforms

The current framework for road sector planning and management in relation to climate resilience under these six areas have been a specific focus for the review and are presented in the following three sections; Road assets and current KeNHA capacity, Road Sector Planning, and Climate Adaption in Road Planning.

Secondly, the gaps and resulting recommendations from this review are identified and presented in an action plan. The Action Plan is outlined in Section 4.2.

Thirdly, the findings are presented at a dissemination workshop to maximize capacity building of KeNHA.

4.1.3 Road assets and current KeNHA capacity

Asset Management

Asset management is one of the most critical factors in sustaining a resilient road network. Building resilience into the Kenyan Road Network will take many years, and it is crucial to have an overview of where and what the main challenges are. The recent World Bank report *Integrating Climate Change into Road Asset Management* (World Bank, 2017) concluded that the integration of climate adaptation into asset management is feasible with proper leadership and commitment.

With the increases in size of the Kenyan Road Network, there is a corresponding increase in the number and complexity of road assets that must be managed.

4.1.4 Road Sector Planning

The objective of the overarching *Road Sector Investment Programme & Strategy 2010 - 2024* (RSIP) (from 2009/10) is "*to provide good roads for a globally competitive and prosperous Kenya*". Its specific objective is to detail the country's road network infrastructure development and maintenance needs for the medium and the long term in order to facilitate guided, secure, aggressive, timely and quality investment for maximum benefits to the overall economy".

The RSIP covers all road works from construction of new roads to rehabilitation and maintenance utilizing all resources that are expected to be made available.

The RSIP includes:

(i) An outline of a 15-year investment plan; and

(ii) A detailed 5-year implementation programme.

The first implementation programme covered 2010 – 2014, and the priority was given to instituting routine maintenance for the entire road network and planned periodic maintenance to the paved network. The methodological tool has primarily been HDM-4 modelling adapted to Kenyan data conditions. A second implementation programme is under preparation for 2015 – 2019 but is delayed due to lack of data for HDM-4 analyses.

The *Roads 2000 strategic Plan 2013 – 2017* (R2000) aims to combine job creation and maintenance, development, extension of the road network by having a focus on developing and using labour intensive methods as much as possible in a cost effective way. Maximising the use of local labour and materials is mentioned as an important element to ensure an efficient delivery of the RSIP.

Kenya Roads Board Annual Public Roads Programme 2017/18 (APRP) concludes, even though the fuel levy (and the transit toll) provides a stable and growing source of means, that adequate funds for road maintenance are not available, especially considering the existing backlog of maintenance. The latest road network condition survey was carried out in 2009 and at that time about 50% of the roads were in poor condition; however it is expected that a lower percentage of roads is now in poor condition[1] e.g. due to the implementation of RSIP and R2000. The Annual Road Works Programmes (ARWPs) submitted by Road Agencies are reviewed by the Kenya Roads Board and consolidated into the APRP, which forms the basis for allocation of funds. The basis for prioritization of roads is given in the RSIP.

APRP states that based on the available funding, the road authorities in the year 2015/16 planned for maintenance of 49,350 km against the entire road network of 161,452 km, and achieved 36,690 km. The maintenance coverage of the network has decreased over the last six years as shown in the table below. This is attributed to the increase in the cost of construction which does not match with the growth of the Road Maintenance Levy Fund (RMLF) collections. The resources available from RMLF for road maintenance in 2017/18 is budgeted at Ksh billion 63.5.

[1] Source: KRB: APRP 2017/18

Financial Year	Network coverage in kms	% Network coverage
FY 2010/11	73,780	46
FY 2011/12	66,530	41
FY 2012/13	62,890	39
FY 2013/14	61,030	38
FY 2014/15	52,911	33
FY 2015/16	49,350	31

Source: KRB: APRP 2017/18

4.1.5 Climate adaptation in road planning

Kenya's *National Environment Policy, 2013* has a section on transport infrastructure that says: "In regard to transport infrastructure, port facilities, roads, railways and bridges will need to account for rising sea levels and the increased occurrence of extreme weather events and flooding. Kenya is expected to have high growth in the transport sector and a challenge will be to develop the required infrastructure in a low carbon and climate resilient manner".

The *Road Sector Investment Programme & Strategy 2010 - 2024* does not refer to either climate change issues or need for adaptation of the infrastructure, but there is a strong focus on improved maintenance, which is a very important measure for keeping roads resilient.

The *Roads 2000 strategic Plan 2013 – 2017* does also not refer to either climate change issues or need for adaptation, as the political focus is on combining job creation and development/extension of the road network.

Our review of policy and plan documents related to climate change and to road development shows:

- that the threats introduced by climate change for the various economic sectors in Kenya are well recognized at the policy level

- that there is substantially more attention to mitigation in the transport sector than to adaptation of transport infrastructure. This is also underlined in the focus of the requested content of EIAs on how road construction and road use affects the environment[2]

- current road planning documents do not specifically address climate issues and the need for improving the climate resilience of roads

- there is a strong focus on ensuring adequate maintenance of both new and existing roads, which is an important adaptation measure for road infrastructure

[2] See e.g. the sustainability section of Kenya Roads Boards Annual Report for year ended June 2016

The second RSIP implementation programme for the period 2015 – 19 is currently being prepared, and information on how adaptation to climate change will be considered is unknown.

Our review of engineering practices based on the review of NETIP designs and interviews with stakeholders shows that there is an attempt to design a road that is robust towards flooding and problem soils. There is, however, no mentioning of climate change or its implications in the design of road infrastructure. As an example, hydrological calculations are made using historical rainfall values with no climate change factor.

4.1.6 Costs of road disruption

The average cost per km of the proposed NETIP highway between Isiolo and Samatar Road is 1,137,000 USD, excluding contingencies, provisions, and V.A.T. Approximately 9% of this cost is used on drainage and structures, 31% on earthworks, 43% on asphalt, and the remainder on miscellaneous road works. Cost increases from increasing the climate resiliency of the highway is expected to include: increased investments in earthworks including additional earthwork fill and soil treatments and erosion protection, and increases in drainage and structures entailing increasing sizes to increase capacity. The cost of construction of a new road is expensive, but as the following paragraphs describe, the cost of disruptions can quickly meet or exceed the cost of construction.

For every new project, we recommend that the potential impacts to society are analyzed in case of a climate disruption to the road. For some of the lower AADT roads, it may be found that the current approach is acceptable, however, for the higher AADT roads, the cost of the disruptions can quickly cost more than the initial cost of the asset. KeNHA's annual road budget is limited and not directly linked to the costs to society in case of disruption. The challenge may be in correlating these disruption costs back into the annual budgeting.

To highlight the potential benefit from climate resilience of the NETIP road it is relevant to take a look at the potential cost resulting from a disruption to the road section due to a climate incident.

These costs can be divided into the following two main categories:

- costs related to maintenance, cleaning or repair of infrastructure; and
- costs experienced by transport users.

We focus on the second category of costs for the illustration of disruption costs in the example below.

The NETIP corridor is characterized by a lack of alternative routes and available detours for transport users between the cities. Local traffic in cities will normally have alternative routes in case of a disruption of a city road section. Therefore the example shows the impact on the regional and national traffic[3] coming to a standstill due to a potential climate disruption of almost any one of the different road sections along the corridor[4].

The example builds on traffic data from existing reports and studies of various parts of the NETIP corridor. A realistic assumption is that the traffic surveys in previous analyses were not conducted during days with heavy rainfall, so the survey results are not influenced by bad weather conditions. This is important, since this corridor in some sections might be the only passable route in periods with heavy rainfall.[5]

The example builds on traffic data from 10 different road sections spanning the entire NETIP-corridor for a wide variety of vehicle types. The traffic flows differ to some extent across the 10 road sections and vehicle type, this might be attributed to the different regional preferences as well as different timing of traffic surveys in the various previous studies. It can, for example, be noted that motorcycles are more frequent in the first part of the corridor out of Isiolo, while Medium and Heavy Trucks are more frequent in the middle section of the corridor. It should be noted that the traffic forecast for year 2022 is based on traffic data and forecasts from various previous studies on separate road sections. Different data points presents some issues in terms of consistency across the studies, and the combined forecast are thus collated after best ability and the rule that most detailed and recent data have precedence. The combined traffic basis in the example for year 2022 is inter- and extrapolated based on unit rates and traffic growth rates taken from the most recent study[6]. For a more detailed walkthrough of the applied assumptions and traffic data, see Appendix A.

Costs experienced by transport users due to a standstill (waiting period) will be related to the opportunity cost of capital and time.

- The opportunity cost of capital is the foregone use of equipment, i.e. when vehicles are waiting for the roads to reopen they are not in use but there will still be expenses related to owning the vehicles in terms of **depreciation**, **interest payments**, **overhead** and **wages** paid to crew. We assume that an added hour/day of waiting time will reduce the annual number of operating hours with the same amount, i.e. if a truck is expected to operate for 2,000 hours a year then any additional waiting time will be a part of this annual estimate. Private use of vehicles exclude overhead cost and wages, and will only consist of depreciation and interest.

- The opportunity cost of time is the waiting time for passengers and **holding time for cargo**. This opportunity cost of time for passengers differ across **work-related trips** and **non-work related trips**, where the opportunity cost of non-work related trips account for approx. one-third of the time cost for work related trips. The number of passengers per vehicle will greatly

3 Traffic flows at Isiolo and Mandera are not included, since these comprise of a high amount of local traffic.

4 This approach is adopted since the AADT generally is very low across the corridor, available OD-matrices are based on a very limited number of observations, information on travelers preferences are incomplete, and the limited number of alternative routes. Traffic surveys have been conducted for all road sections across the entire corridor, however some traffic data are more than 10 years old. The traffic data are based on information from four different studies.

5 "During periods of heavy rainfall, almost all traffic tends to traverse the entire project from Modogashe to Samatar as it becomes the only passable route". Consultancy Services for Design Review of Modogashe – Samatar Road, Kenya (IDA funded). DRAFT DETAILED PROJECT REPORT VOLUME I - MAIN REPORT. (FEB 2018)

6 Consultancy Services for Design Review of Modogashe – Samatar Road, Kenya (IDA funded). DRAFT DETAILED PROJECT REPORT VOLUME I - MAIN REPORT. FEB 2018

influence the overall time cost per vehicle, and one large bus will thus have a higher time cost than a single car.

The primary aim with this example is to highlight the magnitude of the potential economic transport user cost of disruption based on traffic flows along the corridor. The cost of disruption is estimated for a delay with a duration of one hour and one day respectively.

The road user costs due to a one hour road closure lies within an interval from USD 1,400 per hour to USD 9,150 per hour over the different road sections depending on the specific traffic flow. A 24 hour delay will result in road user costs in the range of USD 33,350 up to USD 212,500[7]. The results shall be viewed only as a first rough indication of costs due to the limited availability of specific data. The calculated costs give an indication of the potential cost to society per route that are not related to maintenance and repair of damaged infrastructure. To calculate the road user cost from a delay, we have applied the "rule of a half" to the cumulative road user cost to account for the issue that not all road user will wait for the road to reopen. Some road users will find other things to do during road closure e.g. some might stay home, change the time for travel start or truck drivers could find other use of their trucks. The results can be used as a first indication to reflect on whether a specific road measure should be considered given the cost of the measure and probability of an incident.

Table 3 lists the road user cost per route in 2022 due to a road closure in 1 hour and 24 hours respectively. The results should be reviewed individually, since it is not possible to aggregate across routes.

Table 3 Road User Cost due to disruption. Traffic level: 2022. Price level: USD 2018

	ROAD USER COST PER HOUR			ROAD USER COST PER 24 HOUR		
	Capital	Time	Total	Capital	Time	Total
Isiolo – Kulamawe	721	690	1,411	16,792	16,564	33,356
Kulamawe - Modogashe	2,564	1,700	4,263	58,672	40,792	99,464
Modogashe – Habaswein	3,530	1,789	5,319	81,850	42,928	124,777
Habaswein - Samatar	6,149	3,001	9,150	140,444	72,026	212,470
Samatar - Wajir	3,238	2,174	5,412	73,269	52,175	125,444
Wajir – Tarbaj	5,952	2,756	8,709	130,264	66,154	196,418
Tarbaj – El Wak	5,766	2,348	8,114	126,327	56,360	182,687
El Wak - Banissa Jn	3,588	1,961	5,549	80,933	47,074	128,007
Banissa Jn - Rhamu	2,502	1,555	4,057	56,856	37,321	94,177
Rhamu - Neboh	2,982	1,987	4,969	68,102	47,677	115,779

Source: *Consultancy Services for Design Review of Modogashe – Samatar Road, Kenya (IDA funded)*. DRAFT DETAILED PROJECT REPORT VOLUME I - MAIN REPORT (FEB 2018). *Consultancy services for the preliminary and detailed engineering design of Wajir - Mandera road (B9)*. FINAL DETAILED ENGINEERING REPORT (MAY 2010). *Design Review of Isiolo - Kulamawe Road*. KeNHA. DRAFT FINAL ENGINEERING REPORT (JAN 2018). *Design Review of Kulamawe - Modogashe Road*. KeNHA. DRAFT FINAL ENGINEERING REPORT (JAN 2018).
Note: Road user costs are not aggregatable across routes, and doing so would result in double counting (some road user will be passing through).
Note: The last road section to Mandera is not included due to a very high traffic level compared to the other road sections, which might indicate a high level of local traffic.

The highest road user costs are found on the road sections Habaswein – Samatar, Wajir – Tarbaj and Tarbaj – El Wak. The values are highly dependent on the specific vehicle type composition and overall traffic level. The opportunity cost of capital is generally higher than the opportunity cost of time for all routes, and this is most prevalent from Tarbaj to El Wak, where the opportunity cost of

[7] Crew receive remuneration for 10 hours a day

capital account for nearly 71 % of the total road user costs. This is due to the specific vehicle composition on the individual routes, since Motorcycles, Minibus and Busses are the only vehicles where the opportunity cost of time per hour is higher than the opportunity cost of capital per hour. The details can be seen in Appendix A.

4.1.7 Estimate of Duration of Road Disruptions and effect of Climate Change

The implications and costs of disruptions to road users are described in the previous chapters. In order to show the additional costs to disruption from climate change, it is necessary to make some assumptions regarding what the duration of typical disruptions could be. For this corridor, it is assumed that delays will be associated with extreme rainfall events that lead to flooding. These disruptions are then assumed to increase as per the median climate change forecasts.

The impacts from an extreme event on drainage structures is difficult to predict. The effects are dependent on the design, construction, maintenance and the intensity of the storm. There is limited research available that correlates a design storm and the damage to a drainage asset when that storm is exceeded, mostly because there are so many variables which affect the damage. Typically, a culvert may only be designed to have capacity for a 10 year storm, although it is often checked against a rarer storm, in this case a 25 year storm to ensure there is no flooding to the roadway.

From the reviews of the consultant’s designs, it is seen that drainage structures are designed for design storm return intervals of 10 to 100 years. Smaller pipe culverts are designed for a minimum of 10 year storm (Q10), where larger box culverts are designed for 25 or 50 year intervals, (Q25, Q50). A small number of bridge structures are designed for a 100 year storm event (Q100).

Disruptions could range from a few hours delay where a culvert’s capacity is exceeded and there is flooding over the roadway, to upwards of a week in case of a major flood event that results in a complete washout of a large drainage structure requiring difficult diversions and repairs. This could be significant in the Lorian Swamp where flooded water on both sides of the road make diversions especially difficult.

Table 4 shows how the probability of an extreme event increases over time along the NETIP corridor. Considering many of the culverts may have a lifespan reaching 50 years it is important to look at the likelihood of extreme events over a longer time period. Using historical rainfall data up to 2015, there is a 64% chance that a 50 year storm will be experienced over 50 years, where looking at projected median climate data from 2090 shows that the likelihood will increase to 75%.

Table 4 Probability of Extreme events near Wajir for service life 2015, 2050 and 2090

2015

Length of Service (years)	Frequency-Recurrence Interval			
	10 year	25 year	50 year	100 year
1	0.10	0.04	0.02	0.01
10	0.65	0.34	0.18	0.10
25	0.93	0.64	0.40	0.22
50	0.99	0.87	0.64	0.39
100	1.00	0.98	0.87	0.63

2050

Length of Service (years)	Frequency-Recurrence Interval			
	10 year	25 year	50 year	100 year
1	0.11	0.045	0.023	0.012
10	0.68	0.37	0.21	0.11
25	0.95	0.68	0.44	0.26
50	1.00	0.90	0.69	0.45
100	1.00	0.99	0.90	0.70

2090

Length of Service (years)	Frequency-Recurrence Interval			
	10 year	25 year	50 year	100 year
1	0.13	0.052	0.027	0.014
10	0.74	0.42	0.24	0.12
25	0.96	0.74	0.50	0.27
50	1.00	0.93	0.75	0.47
100	1.00	1.00	0.94	0.72

Once constructed, it is unlikely that culverts will be replaced until their service life is exceeded. This could result in structural deficiencies such as cracking, or the capacity of the culvert could become undersized for the volume of stormwater experienced. The likelihood of a flooding event also increases for areas which are poorly maintained. Culverts that are partially blocked with silt, sediment or debris will have less capacity resulting in more frequent flooding and potentially more extensive damages.

Following construction, it is recommended that maintenance activities are carried out in a timely manner to ensure maximum capacity for the drainage elements, and that emergency response plans are in place to limit any delays to traffic.

4.2 Action Plan

An action plan is presented based on four pillars of road financing to increase the climate resiliency of the future road network;

Investment Decision Making Framework

(i) For new investments, map out natural hazards that could impact the project using the vulnerability assessment guidelines.

(ii) Ensure precautions are taken to avoid natural hazard areas.

(iii) Where not possible to avoid, ensure additional funds are allocated to aid in investigations, design, construction, and maintenance for high risk areas.

Asset Life Cycle Strategy Adjustments

(i) Ensure a functioning Road Asset Management System (RAMS) is in place.

(ii) Ensure a methodology for adding new and existing assets to RAMS.

(iii) Consider the impact of future climate changes to the service life of new infrastructure (for example, more frequent occurrence of a 50 year storm).

Financing

(i) Financial budgeting for road maintenance should anticipate that maintenance activities will become more expansive and more frequent along with increases in precipitation and extreme events.

(ii) When estimating costs for new projects, financing should consider that future climate projections may require larger/additional drainage assets and earthworks.

Institutional and legal reforms

(i) Vulnerability Assessments analyzing possible climate change impacts on highways should be mandatory for all large projects.

(ii) Emergency response plans should be included as a part of the design work to assist in reduction of traffic delays in case of an natural hazard related incident.

Appendix A Traffic Disruption Assumptions

This chapter lists the assumptions used in the calculations on cost of disruption. A significant limitation with these calculations is the different source and time of the specific values and estimates concerning the specific road network. The estimated traffic flow for 2022 is in most cases based on information on available traffic data for the specific road section in a traffic count year, an annual growth rate as well as the potential diverted and generated traffic. From 2017 and until 2022, the same adopted annual growth rates (%) is applied on all sections, see Table 6.

Exemptions

For the road sections connecting Isiolo – Modogashe, diverted traffic is not presented and is therefore not included in the analysis. For the road sections connecting Modogashe – Samatar, the traffic flow is already presented for year 2022, and no calculation is made.

Table 5 lists general assumptions.

Table 5: General assumptions

	VALUE	UNIT	SOURCE
Exchange rate	0,00994299	USD pr KES	https://www.xe.com/currencyconverter/convert/?Amount=1&From=KES&To=USD
Daily hours paid wage for Crew	10	Hours	Assumption
Hours a day	24	Hours	Assumption
Rule of a half	0.5		Assumption related to consumer loss

Table 7 lists the estimated traffic flow in 2022 (ADT) divided on vehicle type and route. Table 8 lists the opportunity cost of capital and related assumptions. Table 9 lists the opportunity cost of time and related assumptions. Table 6 list adopted traffic growth rates (2017-2022).

Table 6: Adopted Annual Growth Rates (%), 2017-2022, Rural Roads/Highways, medium

	MOTOR-CYCLES	CAR	4WD + PICK-UP[1]	MINIBUS (MATATU)[1]	LARGE BUS	LGV	MGV	HGV1	HGV2
Annual Growth Rates	6%	6%	6%	5%	5%	8%	8%	8%	8%

Source: Consultancy Services for Design Review of Modogashe – Samatar Road, Kenya (IDA funded). DRAFT DETAILED PROJECT REPORT VOLUME I - MAIN REPORT (FEB 2018). Consultancy services for the preliminary and detailed engineering design of Wajir - Mandera road (B9). FINAL DETAILED ENGINEERING REPORT (MAY 2010). Design Review of Isiolo - Kulamawe Road. KeNHA. DRAFT FINAL ENGINEERING REPORT (JAN 2018) and own calculations

Table 7: Traffic flow - ADT 2022

	MOTOR-CYCLES	CAR	4WD + PICK-UP[1]	MINIBUS (MATATU)[1]	LARGE BUS	LGV	MGV	HGV1	HGV2
Isiolo - Kulawe	272	53	23	-	8	2	3	6	3
Kulamawe - Modohashe	669	159	87	-	11	37	61	21	2
Modogashe – Habaswein	312	146	183	21	9	4	44	59	8
Habaswein - Samatar	189	282	234	11	27	11	73	139	61
Samatar - Wajir	38	80	142	10	31	8	57	61	36
Wajir - Tarbaj	7	54	200	3	25	34	210	183	105
Tarbaj - Elwak	4	56	200	3	15	39	203	175	101
El Wak - Banissa Jn	11	65	173	34	13	47	74	59	30
Banissa jn - Rhamu	-	88	104	10	20	34	24	38	25
Rhamu - Neboh	2	139	108	36	18	39	24	44	23

Source: *Consultancy Services for Design Review of Modogashe – Samatar Road, Kenya (IDA funded)*. DRAFT DETAILED PROJECT REPORT VOLUME I - MAIN REPORT (FEB 2018). *Consultancy services for the preliminary and detailed engineering design of Wajir - Mandera road (B9)*. FINAL DETAILED ENGINEERING REPORT (MAY 2010). *Design Review of Isiolo - Kulamawe Road*. KeNHA. DRAFT FINAL ENGINEERING REPORT (JAN 2018) and own calculations

Table 8: Opportunity cost of capital, KES

	MOTOR-CYCLES	CAR	4WD + PICK-UP[1]	MINIBUS (MATATU)[1]	LARGE BUS	LGV	MGV	HGV1	HGV2
New vehicle (KES)	119.350	1.871.667	4.833.357	4.985.500	11.736.000	3.000.000	4.950.000	9.900.000	10.700.000
Overhead (KES)	85.500	757.507	1.824.895	1.483.594	2.701.000	1.112.224	1.240.448	1.240.448	1.708.000
Lifetime (years)	5	10	9	8	8	10	10	10	10
Private use (%)	50%	95%	50%	0%	0%	0%	0%	0%	0%
Annual interest	18%	18%	18%	18%	18%	18%	18%	18%	18%
Aggregate cost	162.100	1.909.542	5.745.804	6.469.094	14.437.000	4.112.224	6.190.448	11.140.448	12.408.000
Annual cost[2]	51.836	424.901	1.335.295	1.586.509	3.540.593	915.030	1.377.465	2.478.913	2.760.962
Annual hours	2.000	370	713	1.800	2.200	1.400	2.000	2.000	2.000
Opportunity cost of capital per hour	26	1.148	1.874	881	1.609	654	689	1.239	1.380

Source: Consultancy Services for Design Review of Modogashe – Samatar Road, Kenya (IDA funded). DRAFT DETAILED PROJECT REPORT VOLUME I - MAIN REPORT (FEB 2018) and own calculations.
Note 1: 4wd and pick-up is a simple average of the two vehicle types. Minibus (Matatu) is a simple average of Matatu and Small bus.
Note 2: The annual payment for a loan based on constant payments and a constant interest rate.

Table 9: Opportunity cost of time

	MOTOR-CYCLES	CAR	4WD + PICK-UP	MINIBUS (MATATU) [1]	LARGE BUS	LGV	MGV	HGV1	HGV2
Number of passenger	1	2,4	2,4	18,25	49	0	0	0	0
Work related trips, (%)	50%	50%	50%	50%	50%	50%	0%	0%	0%
Passenger work time (per hour), KES	243	243	243	243	243	0	0	0	0
Passenger Non-work (per hour), KES	73	73	73	73	73	0	0	0	0
Cargo holding, KES	0	0	0	0	0	486	486	486	486
Time cost per vehicle per hour, KES	158	379	379	2.880	7.733	-	-	-	-
Cargo cost per vehicle per hour, KES	-	-	-	-	-	486	486	486	486
Cost per vehicle per hour, KES	158	379	379	2.880	7.733	486	486	486	486

Source: Consultancy Services for Design Review of Modogashe – Samatar Road, Kenya (IDA funded). DRAFT DETAILED PROJECT REPORT VOLUME I - MAIN REPORT (FEB 2018) and own calculations.
Note 1: Number of passengers is a simple average of the two vehicle types (Minibus (Matatu) and Small bus).

AUGUST 2018
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Annex 1 Vulnerability Assessment Guidelines

COWI

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Acronyms and Abbreviations

AADT	Average Annual Daily Traffic
DEM	Digital Elevation Model
GCM	Global Climate Model
GIS	Geographic Information System
ISRIC	International Soil Reference and Information Center
KeNHA	Kenya National Highways Authority
NETIP	North Eastern Transportation Improvement Project
NDVI	Normalized Difference Vegetation Index
RCPs	Representative Concentration Pathways
RSDP	Road Sector Development Plan
SRTM	Shuttle Radar Topographic Mission
SSA	Sub-Saharan Africa
USDA	United States Department of Agriculture
WB	World Bank

Definition of Terms

Adaptation: Adjustment to the segment, structure or asset in response to actual or expected climatic stimuli or their effects. (IPCC)

Climate Stimuli (Trigger): The changes in mean climate and climatic hazards, which may include changes in temperature, precipitation, winds, etc.

Criticality: The importance of a segment, structure or asset of a roadway network.

Mitigation: The lessening of the potential adverse impacts of natural hazards and the effects of climate change upon those hazards. (IPCC)

Sensitivity: The degree to which a segment, structure or asset may be affected when exposed to climate variability or change or natural hazards.

Resilience: The ability of a system (roadway network) to anticipate, absorb, accommodate or recover from the effects of a hazardous event in a timely and efficient manner, including through ensuring the preservation, restoration, or improvement of its essential basic structures and functions. (IPCC)

Vulnerability: The propensity or predisposition to be adversely affected. (IPCC)

1 Introduction

1.1 Purpose

The purpose of this guideline is to aid KeNHA in assessing the vulnerabilities of existing and new road projects in order to mitigate the effects of a changing climate and to support development of a robust roadway network throughout Kenya. The vulnerability screening will give more confidence in the location of new road roads, aid in maintenance strategies, and identify the criticality/redundancy of selected roads.

Results attained through this Assessment can not only be utilized to suggest adaptation measures specific to the corridor, but to identify areas in the planning and design process where readily available data and design approaches could be improved. These recommendations for technical and policy adaptations aim to have an influence on planning, design, engineering and construction methods in future development of the Kenyan road network.

1.2 Target Audience

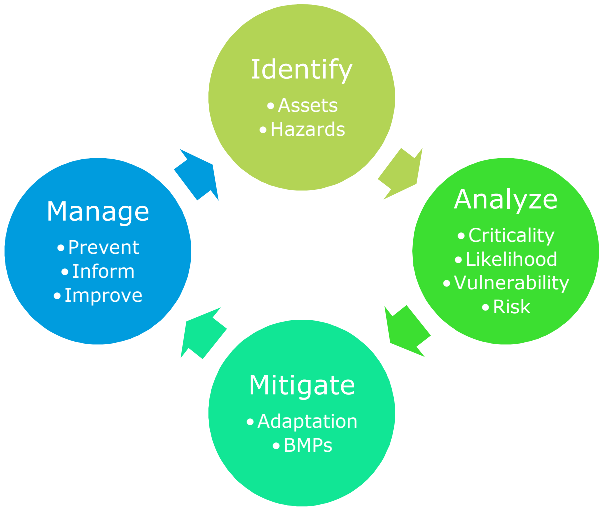
This guide was developed as a tool for KeNHA personnel and their design consultants; those who are involved with the planning, review, and execution of highway and highway-related infrastructure projects. The audience includes senior officials involved in the initial planning stages, mid-level managers developing assessment plans and procedures and field personnel who will conduct the assessments of critical assets.

Similarly, the process can be reiterated throughout the highway and network development process:

- Project Preparation: This phase includes new projects and those in the upgrading and rehabilitation phase. It is the recommended that the guideline be used for initial screening during the feasibility stage, and can be used for all projects from new alignments to road upgrading projects.
- Construction: The Construction phase is the implementation phase. The important determining factors are costs, scheduling, materials, and storm water management.
- Maintenance: The maintenance phase is the most critical phase for ensuring that a highway lives up to its design life. The vulnerability analysis will be used to identify the areas where maintenance shall be prioritized or where preventative measures can be beneficial.
- Operations: The Highway Operations phase can use the guideline to identify key detour routes and detour options that can be utilized in the case of a disruption. The Key vulnerable assets identified shall be highlighted in the asset management system.

1.3 General Approach

The guidelines contained herein provide a four stage process for conducting a vulnerability assessment of a roadway corridor. The steps illustrate a simple, iterative approach that is replicable and scalable across a broad range of highway projects and uses readily available software and data. The outcome aims to identify cost-effective countermeasures to provide a more robust and climate resilient network.



As illustrated above, the assessment process will help the assessor to identify, quantify and prioritize consequential areas along the project corridor. This is performed through the following steps:

- Compile natural hazards and existing conditions data
- Identify and select relevant assets
- Analyze the criticality of key assets
- Apply vulnerability scoring for likelihood, damage and frequency, if available
- Perform consequence analysis, combining the Criticality and Vulnerability ratings, which can be expressed as follows:

Q = V x C

where,

Q = Consequence: The level of importance of an asset, as ranked by criticality and vulnerability. Higher consequential assets are those which much be prioritized for maintenance and mitigation in order to maintain a level of service along a corridor or within a road network.

V = Vulnerability: How much and how likely the asset would be damaged or destroyed if affected by a natural hazard or by the effects of climate change upon that threat.

C = Criticality: How important an asset is to the roadway network and to the safe and continuous flow of traffic and goods.

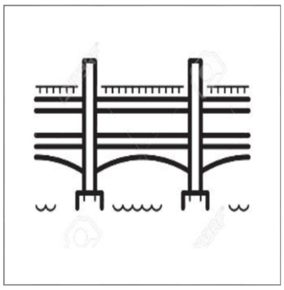
Once the consequence of a corridor's assets are defined and prioritized, adaptation measures can be assigned on a cost-benefit basis.

2 Required Resources

The vulnerability and consequence assessment guidelines contained herein are designed such that the entire study can be performed using readily available software and computing capabilities. Typical programs include a spreadsheet software such as Microsoft Excel, satellite imagery such as Google Earth, and GIS programs such as QGIS.

Infrastructure Data

Road network information is crucial in the assessment of vulnerabilities and in assigning appropriate adaptive countermeasures. Infrastructure data may come from different sources, depending on the phase at which the assessment is being conducted. If the study is for a new roadway corridor, the design information is what will be used and should be received from the design consultant. If the study is for an existing roadway, design or as-built construction plans may be available, or existing conditions surveys or site investigations will be necessary. In remote areas where site access is limited, dangerous or difficult, unmanned aerial vehicles (UAV) or drones can aid in gathering topographical and existing conditions information.

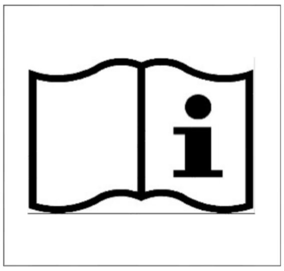


Infrastructure Assets

- Bridges
- Culverts
- Channels
- Retaining walls
- Pavement
- Roadway sections

Infrastructure Data

- Type and Location of an asset
- Dimensional & material data
- Traffic data including counts and axel loading
- Maintenance frequency and existing condition
- Historic events
- Available detour routes, lengths and classification
- Construction costs



In Kenya, it is common that road asset information comes in different formats. Sometimes the asset information is already in GIS format and can be easily opened with an open source GIS program. Often times, the asset information is in a spreadsheet format, or is not yet collected. Importing asset information from Excel to GIS is a straightforward process, however, the data collected must be of a certain quality, it is necessary to make sure that each column has a header, and more importantly, that the coordinates are correct, and contain at least 3 decimals for better accuracy. When collecting information during site visits, it is important to have a plan for which type of data needs to be collected so that it can be easily imported into GIS.

Natural Hazard Data

For a study of the impacts to the highway network, you will need to investigate the potential hazards. Natural Hazard Data can be extracted from the Global Risk Data Platform (http://preview.grid.unep.ch/), a multiple agencies effort in order to share spatial data information on global risk from natural hazards. It covers tropical cyclones and related storm surges, drought, earthquakes, biomass fires, floods, landslides, tsunamis and volcanic eruptions.

Natural Hazard Data

- Type of hazard
- Frequency of occurence
- Damage caused

The natural hazard data available online is typically at a large scale, and its accuracy can be supplemented by local knowledge and experience. Natural hazards such as flooding and landslides that impact the road should be collected with information regarding where the incident occurred, the cause of the incident, and the impact of the incident which can include the cost of damage, as well as the traffic implications.

Current and future expansion of data collection and research activities will also provide improved data for use in the assessment methodology. Especially beneficial to the assessment will be the availability of return period information, or frequency, which will allow the modeling to be augmented to produce a Risk factor, further enhancing the accuracy of the assessment.

Climate Data

In order to perform a vulnerability assessment to climate change, both historical and predicted climate data is necessary. Depending on the asset, different climate data is necessary such as precipitation. Historical data should be obtained through the relevant ministries as done for a road project. If available, local gauged precipitation, temperature, and river flow data should be used. In the absence or insufficiency of local data, climate data are available from The World Bank's Climate Change Knowledge Portal (http://sdwebx.worldbank.org/climateportal/index.cfm). However, the data from the climate change portal is coarse, and may not be accurate for localized areas. Data can be downloaded from this resource and utilized in GIS mapping software.

Climate Data

- Historic & Predicted
- Precipitation
- Temperature
- % Change

Predictions of climate change vary broadly depending on different scenarios, and analyzing the data is typically outside the scope of services a highway engineer can provide. It is necessary for a government organization to inform users which climate predictions should be used.

Cost Data

The assessment of criticality and Consequence of an asset depends on many factors, one of which will be cost of construction, repair or replacement, or the cost of traffic disruption, which, depending on the type and volume of traffic on a specific corridor, may exceed the cost of replacement or repair of a particular failed asset. Current information on costs should be sourced locally, or if available, from engineering design reports.

Cost Data

- Construction costs
- Maintenance costs
- Repair or replacement costs
- Traffic disruption costs

3 Vulnerability Assessment Guidelines

3.1 Step 2: Identify Key Assets and assign Criticality

Part of the development of the Vulnerability Assessment is to produce easily understood criticality rankings for an asset or section of roadway, which will be included to calculate the vulnerability to a hazard and consequence if the asset were damaged. This will help to optimize the selection of mitigation options and reduce the impacts from, or chance of failure.

Many factors are involved in the calculations and, depending on the size of the study corridor, it may be unfeasible to analyze all assets. To narrow the field of investigation, we will first identify Key Assets, whose characteristics will be examined to develop a ranked list of Critical Assets.

3.1.1 Identify Key Assets

To identify Key Assets along a study corridor is a subjective process and will vary from study to study. Along a study corridor, approximately 25-30% of the total assets (e.g. bridges, culverts, retaining walls, road sections) could be considered for further investigation. These assets will be those most critical to the function of the roadway.

Factors to consider in the screening process for Key Assets:

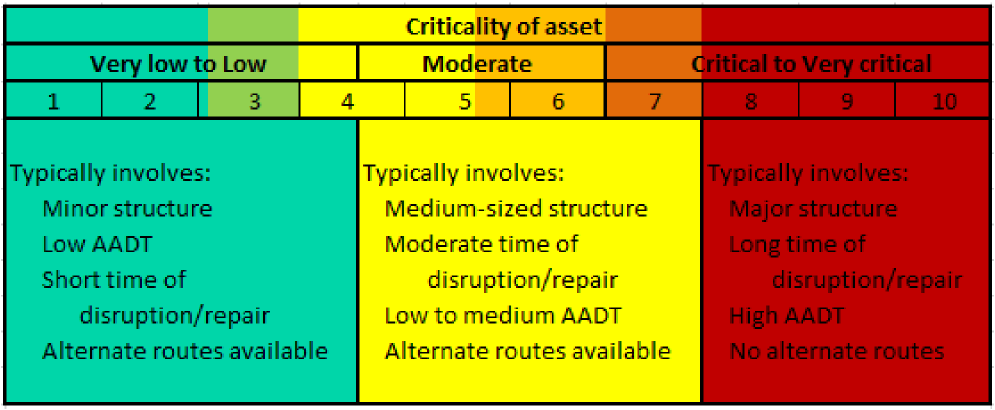
- Location: If drainage structure is to convey a large watershed area. If a retaining wall or drainage channel is situated in erosive or unstable soils. This can be identified by e.g. design reports, soil mapping or by satellite imagery.
- Natural Hazards: A preliminary screening of natural hazards is suggested to identify areas where the study corridor may be more susceptible to impacts from e.g. flooding, landslides, or earthquakes.
- Dimensional data: The size of an asset such as a bridge or retaining wall may suggest that it be included as a Key Asset.
- Criticality factors such as those listed in Table 1
- Local Knowledge: Local operations and maintenance staff, design and construction engineers, traffic engineers and field personnel may have valuable information on which assets should be considered.

For the initial screening of the assets, InaSAFE http://inasafe.org/ can be used freely within QGIS to easily overlay road assets and natural hazard data. This will result in a quantity of roads or assets which are in a natural hazard area. Assets located within the exposed areas will be a good place to start a vulnerability analysis.

3.1.2 Assign Criticality Score

Once the Key Assets have been identified, they will be classified by their criticality: Low, Moderate or High, on a scale of 1 to 10. The criticality scoring of an asset is assessed based on the chart in Figure 1, where the least critical assets receive a score of 1 and most critical are scored as 10. Criticality is calculated based on the impacts to the road network if that asset were to fail. For example, a highly critical asset would be a large, high capacity drainage structure in an area with no detour route. A low critical asset would be a small culvert that would be easy to bypass with traffic and quick to repair.

Figure 1 Criticality Scoring of an Asset



The following Critical Asset Factors are used in assigning critical asset factors and values:

Table 1 Critical Asset Factors and Descriptions

Critical Asset ID and Factor		Description
A	Casualty Extent	How substantial could failure or damage result in serious injury or loss of life?
B	Replacement Cost	How significant would the cost of repair or replacement be?
C	Traffic Disruption	How long would traffic be stopped or re-routed if the asset fails? How long to repair the asset until the road is passable?
D	Alternate Route Available	Is there a reasonable detour route? How long is it?
E	Asset Size/Complexity	Is the asset a bridge or a small culvert? How large is the watershed draining to a bridge or culvert? How high is the retaining wall?
F	Economic impact	How severe would the impact of failure or damage to an asset have on the means, resources or wealth of a region?
G	Adaptability	How adaptable is the asset? Could countermeasures be implemented to reduce vulnerability?

Each of these critical asset factors can be assigned subjectively based upon general information known about the asset or the area, or the factor can be calculated utilizing actual data, if available. Each asset will receive a score between 1 and 10, which then will be added together to get a Total Score (x). An example scoring sheet is shown in Table 1Table 2.

Table 2 Critical Asset Scoring Sheet

Key Asset ID	Critical Asset Factor							Total Score (x)	Total Score (X)
	A	B	C	D	E	F	G		
Asset 1	1	9	5	1	1	8	1	26	72
Asset 2	8	10	2	4	1	8	1	34	94
Asset 3	6	2	8	5	5	5	3	34	94
Asset 4	5	4	7	9	4	5	2	36	100
Asset 5	4	8	2	2	4	1	8	29	81
Asset 6	2	4	4	1	2	1	6	20	56
Asset 7	4	2	2	1	2	4	4	19	53
	Maximum score (x_{max}):							36	

The Total Criticality Score (X) is calculated as follows:

X = Criticality = $(x/x_{max})*100$, where

x_{max} = the maximum criticality score along the corridor, which varies.

This Criticality Score will then be combined with the Vulnerability Score to determine the consequence ranking of each asset.

3.2 Step 2: Assess Vulnerability

The vulnerability assessment is designed to identify and evaluate critical assets with regards to their susceptibility to and impact from natural hazards, especially those which can be amplified from climate change.

The method described herein is based on historical evidence and available hazard mapping. If hazards, for example landslides, have occurred near the asset in the past, then there is a high likelihood that a landslide can occur in the future. If there is no historical evidence of landslides, but the location is landslide prone, then the likelihood will be moderate. This assessment is greatly influenced by the assessor's knowledge of the hazard and area.

The effect of climate change plays an important role in the assessment of vulnerability.

3.2.1 Likelihood Scoring

The first screening for vulnerability is to investigate the natural hazards that may affect an asset. Utilizing GIS software, the road corridor and Key Assets can be mapped against the historical natural hazards in the region such that the assessor can visualize what hazards may have an impact on the corridor and individual or groups of assets. Using the shortened list of Critical Assets defined under Step 1, a Likelihood Factor, listed in Table 3, can be assigned.

Likelihood Scoring

In order to rank assets according their vulnerabilities to natural hazards, values must be assigned for the natural hazards that are crossed. Natural hazards are scored by two values, Likelihood Factor (A) if the road asset is in proximity to the hazard and the expected impact of the hazard occurring, and the Damage Factor (B) is a scaled value based on the estimated damage on the road asset if the hazard were to occur. For example, flooding and landslides have the potential to cause severe damage to the roadway, whereas a wildfire or drought will have a smaller impact to a roadway.

Table 3 Vulnerability Scoring Factor (A) – Likelihood/Proximity

Factor	Description	Score
(A) Likelihood of a Natural Hazard	High Likelihood (shown on Hazard map and historical evidence of hazard near asset)	2
	Moderate Likelihood (shown on Hazard map, with no experience of hazard occurring near asset)	1
	Low Likelihood (not shown on hazard map and no historical evidence of hazard)	0

As the data for natural hazards are improved, it may be necessary to add additional scoring levels.

Table 4 Damage Factor (B)

Code	Natural Hazard	Damage Score (B)
Fl	Flooding	10
Ls	Landslide	8
Eq	Earthquakes	10
Hw	Heatwave	3
Wi	Wildfires	1
Dr	Drought	1
Ts	Tsunamis	10

By screening the natural hazards against the Critical Assets, the Vulnerability score can be assigned. A manual sample scoring sheet is shown in Table 5, where relevant Vulnerability Factors that may affect an asset are summed.

Table 5 Vulnerability Scoring

Critical Asset ID	**Vulnerability Factor**																							**Total Score**
	Fl				Ls				Eq				Hw				Wi				Dr			
	(A * B)			+	(A * B)			+	(A * B)			+	(A * B)			+	(A * B)			+	(A * B)			
	0-1	*	10	+	0-1	*	8	+	0-1	*	10	+	0-1	*	3	+	0-1	*	1	+	0-1	*	1	
Asset 1	1		10		0		8		0		10		1		3		1		1		1		1	15
Asset 2	0		10		1		8		0		10		0		3		0		1		1		1	9
Asset 3	1		10		0		8		0		10		0		3		0		1		1		1	11
Asset 4	0		10		0		8		0		10		1		3		1		1		1		1	5
Asset 5	0		10		0		8		1		10		0		3		0		1		1		1	11
Asset 6	1		10		0		8		0		10		0		3		1		1		1		1	12
Asset 7																								
																				Maximum Score:				15

The total score of the vulnerability factor (y) = Fl(A * B) + Ls(A * B) + Eq(A * B) + Hw(A * B) + Dr(A * B) where the lowest possible score is 0 if no hazards are present.

The total score (y) will then be used to calculate the Vulnerability coordinate of each asset (Y) as follows:

Y = Vulnerability = $(y/y_{max})*100$, where

y = Asset Vulnerability score

y_{max} = the maximum Vulnerability score along the corridor, which varies.

3.3 Step 3: Consequence Assessment

The consequence assessment will identify assets which are subject to the greatest possibility for failure given a set of circumstances and conditions. The assessment is based on an integrated analysis of the data collected on critical assets and vulnerabilities to known natural hazards, in combination with the effects of a changing climate.

3.3.1 Consequence determination

In this step, the Criticality and Vulnerability scores that are calculated for each asset are combined to create a ranking of Consequence. Visually, a matrix chart such as that shown in Figure 2 will help to identify the assets that should be of highest priority for application of countermeasures.

The formulas developed under Steps 1 Criticality, and 2 Vulnerability, were used to plot X and Y coordinates:

X = Criticality = $(x/x_{max})*100$, where

x = Asset Criticality score

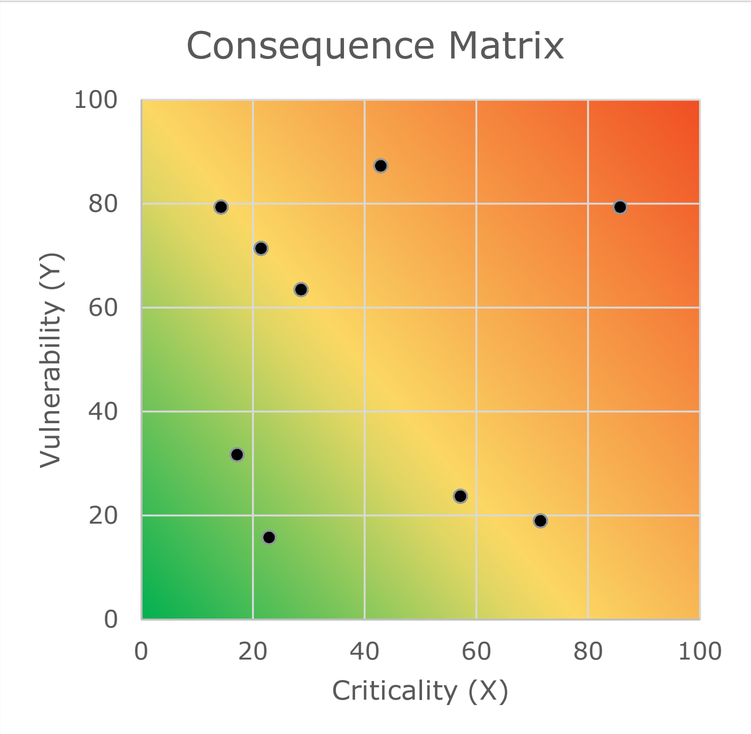
x_{max} = maximum Criticality score along corridor, which varies

Y = Vulnerability = $(y/y_{max})*100$, where

y = Asset Vulnerability score

y_{max} = maximum Vulnerability score along corridor, which varies.

Figure 2 Sample Criticality / Vulnerability Matrix.



Highly consequential assets, those that fall into the upper right quadrant of the matrix, should be prioritized for adaptation measures. These assets should be investigated on an individual basis to determine what the most critical and most vulnerable issues are, and what adaptation methods would be appropriate and most cost effective for implementation.

Since the criticality and vulnerability assessments are both largely subjective, the analysis can really only be compared within the project area. For example, a pipe culvert on Road A may be ranked just as consequential as a large bridge on Road B, due to the multitude of factors described above.

3.4 Step 4: Identify and Prioritize Adaptations

This step will investigate appropriate adaptation measures that can be applied to high-priority assets identified in the previous step. Adaptations, or countermeasures, are intended to protect an asset from the hazards and vulnerabilities that are indicated to affect an asset. Adaptations may involve a change in design parameters, rehabilitation methods, or policy and procedural modifications and can be categorized into two disciplines; Technical Adaptations and Policy Adaptations.

The tables below contain a collection of possible adaptation methods that are applicable to the vulnerabilities observed in Kenya.

Table 6 Technical Adaptation Measures

Adaptation Measures	Vulnerable Asset	Benefit	Time Horizon	Cost
Use heat-resistant pavement materials	Pv	2	1	1
Use modified binders to reduce rutting and cracking	Pv	2	1	1
Use flexible materials	Pv	2	1	1
Use surface reflectance	Pv	2	1	1
Increase capacity and frequency of drainage structures	Br, Cu, Ch	1	2	2
Reduce gradient of slopes	Ew, Ch, Rw	1	2	2
Use erosion control measures (blankets, riprap, check dams, miter drains, energy dissipaters)	Ew, Ch, Rw, Br, Cu	1	1	1
Use slope protection methods	Ew, Ch, Rw	1	1	2
Increase surface water retention and capacity	Br, Cu, Ch	1	3	1
Raise road surface level (e.g. above expected flood elevations)	Ew, Br, Cu, Ch	1	2	3
Relocate roadway (e.g. away from flood areas or steep slopes)	Ew, Br, Cu, Ch, Rw	3	3	3
Use water capture storage systems	Ew, Ch	2	2	2
Realign natural/manmade watercourses	Ew, Ch	3	2	3
Enclose materials to protect from flood water	Ew, Ch, Br, Cu	1	1	1
Stabilize/line roadside channels	Ew, Ch	1	1	1
Use drought-resistant materials	Pv, Ew	3	3	1

Vulnerable Asset Codes:

- Pv – Pavements
- Ew - Earthworks

- Br – Bridges
- Cu – Culverts
- Ch – Channels
- Rw – Retaining Wall

Benefit Ranking: 1 - High Benefit, 2 – Moderate Benefit, 3 – Low Benefit

Time Horizon Ranking: 1 – Immediate (6 – 12 months), 2 – Moderate (1 – 2 years), 3 – On-going (2 – 10 years).

Cost Ranking: 1 – Low, 2 – Moderate, 3 – High. Assumes capital investment cost of a new asset, not adaptive or rehabilitation cost of an existing asset. Costs are discussed in detail in Section **Error! Reference source not found.**.

Ease of implementation: The complexity for which the policy adaptation may occur. 1 – Low (single ministry/department action) 2 – Moderate (Inter-departmental action) 3 – High (broad legislative or capacity requirements)

Table 7 Policy Adaptation Measures and Implementation Complexity

	Adaptation Measures	**Priority/ Benefit**	**Ease of Imple-mentation**	**Time Horizon**	**Cost**
Legislation	Encourage pro-active approach to climate resilient planning, technology and construction.	1	1	1	1
	Modify tender selection criteria to allow for climate resilient project design/construction.	1	2	1	1
	Implement axel-weight restrictions during extreme temperatures.	2	3	1	2
Capacity improvements	Develop network redundancy and detour routes.	2	3	3	3
	Expand network and asset monitoring and maintenance activities.	1	1	1	3
	Expand research and data collection activities for precipitation and stream gauging, construction materials and response and repair activities.	2	2	2	1
	Update planning, design and construction specifications for climate resilience. Continually update in response to collected data and recent events.	1	3	2	1
	Improve emergency communication methods. Implement or expand emergency warning systems. Develop emergency management and response guidelines.	2	3	2	1
Planning &	Plan new roads away from high-risk areas.	2	2	2	1
	Develop network redundancy and detour routes.	1	2	3	2
	Use drainage and road design specifications that account for climate change factors to improve drainage capacity, to lower slope angles for cut/fill	1	1	1	1

	slopes, and that specify climate resilient construction materials.				
	Perform site specific soil and slope stability studies.	2	1	1	1
	Specify erosion controls, stabilized slopes and channel lining.	1	1	1	2
	Redesign especially vulnerable assets to account for climate change.	3	3	3	2
	Review of construction methods and materials during event response and redesign if necessary.	3	2	2	2
Construction	Upgrade or retrofit vulnerable assets or network sections.	2	2	2	2
	Perform new construction using climate resilient methodology and materials.	1	1	1	1
	Install erosion controls. Stabilize slopes. Line channels.	1	1	1	2
	Develop emergency construction guidelines and pre-approved contractors list.	2	2	2	1
	Perform corrective works. Construct permanent repairs and structures, as necessary.	2	2	2	2
Monitoring & Maintenance	Increase frequency of network monitoring and maintenance activities, especially in vulnerable areas.	1	1	1	1
	Increase frequency of sediment dredging of rivers and channels to provide adequate drainage conveyance capacity.	1	1	1	2
	Perform repair activities quickly after discovery of a deficiency.	1	1	1	1
	Check vulnerable assets and areas for structural stability before rainy season or expected high temperatures.	2	1	1	1
	Monitor network functions and response/repair activities.	2	1	1	1
	Provide monitoring and maintenance activities during response and recovery periods to ensure repairs or compromised assets continue to operate sufficiently and safely.	2	1	1	1

3.4.1 Assess countermeasure effectiveness

The effectiveness of an adaptation is measured subjectively by assessing how well its application to an asset reduces that asset's vulnerability. In some cases an asset may be vulnerable to several elements, in which case the vulnerabilities could be investigated individually to prioritize the mitigation actions.

3.4.2 Costs

Part of the adaptation strategy selection process will be to investigate the costs associated with a particular countermeasure activity or set of activities. If an adaptation measure has a high impact and costs little, then it is highly advantageous. If the impact is low but the cost is high, perhaps a different strategy should be found. In many cases, a combination of activities will be incorporated together in order to achieve a resilient asset.

The capital investment and annual operation and maintenance costs for countermeasures will vary widely depending on the region and cost of materials. If applicable, cost estimates from the consulting engineering firm can be utilized.

Table 8 Costs per Kilometer (USD/km), for use with Table 9

	Capital Investment	Annual Maintenance Cost
Low	< $100K	< $50K
Moderate	$100K - $500K	$50K - $100K
High	>$500K	>$100K

Table 9 Adaptation Capital Investment and Maintenance Costs

Adaptation Measures	Capital Investment	Annual Maintenance Cost
Use heat-resistant pavement materials	L	L
Use modified binders to reduce rutting and cracking	L	L
Use flexible materials	L	L
Use surface reflectance	L	L
Increase capacity and frequency of drainage structures	M	L
Reduce gradient of slopes	L	L
Use erosion control measures (blankets, riprap, check dams, miter drains, energy dissipaters)	M	M
Use slope protection methods	M	M
Increase surface water retention and capacity	L	M
Raise road surface level (e.g. above expected flood elevations)	M	L
Relocate roadway (e.g. away from flood areas or steep slopes)	H	L
Use water capture storage systems	M	M
Realign natural/manmade watercourses	M	M
Enclose materials to protect from flood water	M	M
Stabilize/line roadside channels	M	M
Use drought-resistant materials	L	L

At the same time, the cost of disruption to traffic must be considered. Depending on the traffic load and types of vehicles traveling along a particular section, the costs incurred by a delay could outweigh the cost of construction or repair of an asset. This indicates that prevention of an asset failure by implementation of countermeasures may be more cost-beneficial to repair.

Once the high priority assets are identified, detailed cost estimates can be prepared.

Annex 2 TOR

1.1 TOR for Network level climate vulnerability assessment

The TOR for the follow up vulnerability assessment is based off a recent World Bank TOR for Strengthening the Integration of Disaster Risk Management and Climate Resilience in Road transport to improve Trade and competitiveness in the Western Balkans Region as well as lessons learned from this project which has focused on the NETIP corridor. A vulnerability assessment using only GIS tools will have difficulties in identifying these areas as the terrain is relatively stable, and there are only a few large rivers passing through this section. A vulnerability assessment must therefore be based on historical visual evidence as well as GIS based.

There are select international trade routes, as well as domestic corridors which have a higher proportion of influence on the economy of Kenya, and it is these key routes which shall be assessed and ensured to remain operational at all times. One of the main challenges for Kenyan transport is its lack of redundant road corridors. In areas where there are no alternate routes, the potential loss to the economy could be high in case of a long term disruption.

It is recommended that as a part of the follow up vulnerability assessment, the first task is to identify the economic importance of each major corridor of the Kenyan Road Network. This is an important step to help communicate that it is not only for KeNHA’s sake that these roads are maintained or adapted, but that the entire country either benefits when they are well functioning, or loses money when they are not. By knowing the potential loss to the country’s economy, it will be easier for KeNHA to ensure that the funding necessary to maintain and improve vulnerable sections of strategic roads is made available. The purpose of having good roads is for the country to improve economically. KeNHA’s challenge in the future is ensuring that the limited resources available are used in the most appropriate locations. It may not be cost beneficial to climate proof corridors that may only add a small benefit to the economy. The economic assessment should not only look at existing roads, but also investigate the strategic importance of future roads.

After a comprehensive understanding of the economic importance of the different corridors is reached, the vulnerability assessment can begin. The vulnerability assessment will start with a high level screening of the entire network based on GIS. The level of available data in Kenya is still low at this time, and the high-level screening will only give an indication of where natural hazards are expected. There will always be vulnerable areas that will not be picked up by the high-level screening, but it will give an indication of how dense the threat level is along each corridor. The vulnerability assessment will be more detailed for the strategically important corridors. For the most important corridors, it will be necessary to analyse what the likelihood for disruption will be, and how transport will get from origin to destination in case of disruption. This will require analysing emergency response times, as well as options for detours. Disruption costs will be necessary to decide on which adaptation measures are appropriate, which could include increasing emergency maintenance funding, improving link roads to act as detour routes, or climate proofing certain sections of road.

The outcome of this follow up work will be an additional level of understanding for KeNHA of the costs from natural hazard disruptions to the road network as well where it is most economically beneficial to invest in improvements.

Cost Estimate

It is expected that this work will require 8 months to complete from signing of contract to final deliverable. Data collection can be difficult in Kenya and it is important that enough time is allowed for the consultant to acquire sufficient data to continue the work.

Cost Estimates for the inputs from suggested Key Experts and expenses is summarized below:

Breakdown of Daily Fees			
Key Expert	**Number of Days**	**Daily Fee (USD)**	**Total Cost (USD)**
Team leader	100	900	90000
Senior Disaster Risk Assessment Specialist/climate change specialist	40	850	34000
Disaster Risk Modeller/flood risk modeller/landslide expert	40	850	34000
Senior economist/ trade and transport facilitation specialist	30	850	25500
Road and bridge engineer	30	700	21000
Geotechnical engineer	20	700	14000
GIS/Mapping Specialist	40	600	24000
Sub-total			242500
Breakdown of Reimbursable Costs			
Description	**Quantity**	**Unit Price**	**Total Amount**
International travel:			
- **Airfare**	12	1000	12000
- **Hotel**	60	120	7200
- **Meals and Incidentals**	60	80	4800
Local Travel and Office :			
- **Ground transportation(car)**	20	250	5000
Field Surveys	1	25000	25000
Printing costs (approx 6 x 500 pages)	3000	1	3000
Workshops/meetings	4	2000	8000
Subtotal			65000
Total for Project (USD)			**307500**

THE WORLD BANK

STRENGTHENING THE INTEGRATION OF DISASTER RISK MANAGEMENT AND CLIMATE RESILIENCE IN ROAD TRANSPORT IN KENYA

TERMS OF REFERENCE

Background

Many sections of the Kenyan road network are vulnerable to natural hazards and climate change. However, some corridors have a greater effect on the overall growth of Kenya's economy than others. In order to increase the resiliency of the network, KeNHA must be ready at all times to respond to any disruptions to the road caused by Natural Hazards which climate change projections are showing will increase in likelihood in some areas of Kenya over the next 100 years. KeNHA can increase their resiliency by focusing on three main aspects:

Design
Maintenance
Emergency Response/Redundancy

Design can be made more resilient by ensuring that there are safety factors which allow for a range of climate change scenarios applied. Roads can be made more resilient by ensuring that designs are improved in areas of high vulnerability.

Maintenance is the most important factor for increasing the resiliency of Kenya's road network. There have been many improvements in maintenance over the years in Kenya, with large focus on maintaining the asphalt surfaces, and increasing the percentage of roads in good condition. A lapse of lack of maintenance will only amplify any impacts from climate change. A bridge or culvert with reduced capacity due to sedimentation or with scouring problems will be much more sensitive to any increases in precipitation than a well-maintained asset.

Having a resilient network means being able to cope with any disruptions to the network in a well-timed manner resulting in the minimum amount of socioeconomic impact on Kenya. Although Kenya is expanding their network, the options for detour routes in case of disruption are still limited in some areas. With the expansion of the network, the need for emergency response resources becomes more critical.

Objectives of the proposed activity

The Objective of this proposed activity is to identify the most vulnerable sections of the Kenyan Road Network whose disruption will have the greatest economic impact on the country. In addition, this project will support the development of a more climate resilient Kenyan Road Network. To this end, the activity will assess the economic impacts associated with the potential disruption of road network assets in terms of infrastructure related losses and the loss of functional connectivity as a function of time among other dimensions. The sub-activities will therefore be, in summary: 1) Collection of all existing and useful data and information on hazards and transport/regional trade to determine areas along Corridors which are potentially high risk and need more investigation, b) Modeling of the impact of disasters (current and with climate change and socioeconomic changes) on these major transport corridors in the high risk areas identified, c) Cost-benefit analysis of engineering actions to reduce transport actions considering climate and socioeconomic changes.

The findings will support policy and institutional development relating to trade, transport infrastructure, natural hazards and climate related impacts and sustainable development.

More specifically, the objectives of the proposed study shall be operational and usable by the authorities in Kenya. The outputs delivered by the proposed study shall be actionable and consists in scenarios that help for decision making.

Scope for the proposed activity

The geographic coverage of the project is Kenya. The emphasis of the project is KeNHA's A, B and C classified Road Network which covers approximately 14,000 km. In addition, the project must consider the suitability of D and E classified roads as temporary diversion routes in case of disruption. Important trade routes to the neighbouring countries must also be considered.

The scope of work shall include but not be limited to the following Tasks:

Task 1. Adapting existing vulnerability assessment to include all natural hazards and data collection.

Task 2. Determine the socioeconomic importance of the different corridors of the Kenyan Road Network.

Task 3: Climate change and natural hazard road network vulnerability assessment.

Task 4: Prioritize improvements and cost estimates.

Task 5: Training and capacity building of technical staff on climate change risk assessment for sustainability of interventions.

The minimum requirements under each task are provided below:

Task 1: Data Collection and Updating of Vulnerability Assessment

The Consultant shall collect all necessary data in order to assess the economic importance of disruption of Kenya's Road Network, and data necessary in order to perform a vulnerability assessment for the entire Road Network.

Sub-task 1.1: Data Collection and Consultations:

- The consultants shall gather data on current and historical climate, geological, hydrological, seismological and socioeconomic information, including projections of future climate under different scenarios.
- Collect data on transport infrastructure and existing traffic flows (multimodal approach).

Sub – task 1.2: Socioeconomic data review:

- Collect and review legal and organisational framework in Kenya for roads, as well as Government development plans.
- Collect and review demographic and socioeconomic data and identify areas with high densities of population, especially the poor or other groups of vulnerable people. Based on collected data identify the location of critical services and major economic activities, existing and planned. The Consultant shall determine the most adequate level of dataset and consolidate the data based on the needs for the studies.
- Undertake a critical assessment of the economic potential of high-risk areas and rank these on a rigorous methodological analysis that the Consultant proposes.

Sub-task 1.3: Adapt Guidelines for climate change and natural hazard road network vulnerability assessment

Present the proposed methodology in the form of guidelines. The methodology will be based on the 'Guidelines for Climate Change and Natural Hazard Road Network Vulnerability Assessment in Kenya'.

Expected outputs from Task 1: Guidelines for climate change and natural hazard road network vulnerability assessment, as well as all the data from Sub-task 1.1 and 1.2 in a geospatial dataset base, and a non-geospatial dataset.

Task 2. Determine the socioeconomic importance of the different corridors of the Road Network.

Determine the socioeconomic importance (including connectivity and trade flows) of the main Kenyan Road Network corridors to identify the areas of the corridor on a regional level that are most critical to avoid disruption of roads access. The consultant shall use a methodology which allows for systematic ranking of the socioeconomic importance of disruption of the main corridors of the Kenyan Road Network which can be used as a criticality factor for the vulnerability assessment in task 3.

Expected outputs from Task 2: Map in GIS showing socioeconomic importance of each major corridor of the Kenyan Road Network.

Task 3. Climate change and natural hazard road network vulnerability assessment.

Sub-task 3.1: Identify relative exposure of Kenya to natural hazards, for baseline & future year scenarios

- The consultant shall define appropriate indicators and required data to asses each type of hazard following the results from Task 1.

- Update, modify and harmonise hazard input datasets as necessary to ensure the datasets are as complete as possible for analysis for baseline and future climate projections.
- Analyse data to produce regional map of relative exposure to natural hazards.

Sub-task 3.2: Identify parts of the Kenyan Road Network on a regional level that cross areas of High Levels of exposure to natural hazards

- The consultant shall overlay the Kenyan Road Network map with natural hazards exposure maps
- Identify critical links identified in Task 2 that cross areas of high exposure to natural hazards for current year, medium and long term.

Sub-task 3.3: Carry out engineering based assessment of critical areas of the corridor on a regional level to estimate their vulnerability to natural hazards and their risks

- Based on the list/map of main road links that pass through areas of high level exposure to natural hazards, the consultants shall carry out screening level engineering inspection of the most vulnerable sections.
- For each type of natural hazard, estimate the level of exposure and vulnerability to each type of hazard of the assets along the critical corridors.
- Identify risks based on specific design and condition weaknesses.

Expected outputs from Task 3: Current year, medium term and long term natural hazard exposure map with appropriate indicators; List/map of main road links that pass through area of high level exposure to natural hazards; List/map of assets (and design weaknesses) with highest risk from natural hazards.

Task 4. Prioritize improvements and cost estimates.

Sub-task 4.1: Assessment of the economic potential losses of road network assets, direct physical impact (damages), and the losses of functional connectivity

- The consultant shall evaluate economic potential losses of corridor assets on a regional level in terms of physical damages (direct) and in terms of losses due to reduced economic activities in the region. Evaluation shall be carried out on a high/regional level.
- The consultants shall look at criticality and risk from a multimodal point of view and evaluate contingency measures including modal shift to enable unimpeded flow of traffic along alternative corridors in case of disruption. The consultants will identify critical transport links that could serve as important means of escape, access to emergency relief or for the transport of agricultural or other economic assets.

Sub-task 4.2: Preparation of methodology for a regional contingency planning

- Develop regional transport management plans (from an operational / traffic management plan angle) taking into consideration the specific institutional and policy arrangements, relevant authorities, their interaction, response time, laws that govern the sector, etc.

Sub-task 4.3: Identify the sections of the network with the largest economic influence on Kenya and evaluate cost site-specific engineering interventions and other non-site-specific interventions necessary to improve the road asset's resilience to natural hazards.

- The consultant shall rank the sections of the Kenyan Road Netwok network in order of the largest economic influences for Kenya.
- The consultant shall identify and cost specific infrastructure (engineering) interventions for the top influential sections of the A classified network which is necessary to improve these core road corridor assets 'resilience to natural hazards'
- The consultant shall identify and cost other non-site-specific interventions necessary to improve these core road corridor assets resilience to natural hazards.
- The consultant shall conduct a survey on firms (questionnaire provided) on how firms deal with disruption (from larger inventories, multiple suppliers, or reduction in just in time) to understand the costs incurred and support decision-making for public investment towards more resilience.
- The consultant shall assess the performance of these different interventions in terms of risk reduction under multiple scenarios for future climate change scenarios (with different impacts on the frequency and severity of hazards) and transport demand.
- The consultants shall identify the vulnerabilities of each intervention (i.e. under which future conditions each intervention would fail to deliver acceptable results) and shall assess the robustness of remedial options to mitigate or remove natural hazards.

Expected outputs from Task 4: For the A classified Road Network, deliver list of tested different operational strategies to increase the resilience of the network (both from the soft and hard perspective) and definition of the most effective one based on the economic performance across a wide range of future conditions, and list of recommended non-site-specific interventions and infrastructure measures on specific assets with their costs and prioritised according to their risk from natural hazard.

Task 5: Use Multi-Criteria Analysis (MCA) to prioritize the list of specific interventions in order to obtain a Road Map for financing of prioritized intervention

- The consultants shall define specific criteria and its importance for prioritisation of specific interventions (hard and soft).
- The consultants shall assign multi-criteria prioritisation methodology to specific interventions. This methodology shall use the multiple scenarios developed in Task 4 by using robustness as a criterion or by testing the different criteria under several climate and disruption scenarios.
- Develop a list of regional interventions with cost estimates to increase the road corridor asset's resilience to the effects from natural hazards and climate change.

Expected output from Task 5: Regional Road Map for prioritized intervention with assessment of their costs

Task 6: Capacity building of technical staff on climate change risk assessment for sustainability of interventions.

The consultant will organize pre-final consultations to validate findings and a final workshop to present the findings. This workshop will also constitute a knowledge dissemination workshop to be attended by high level and technical stakeholders from Kenya.

Expected output: Pre-final Consultations and Workshops

Management and logistical support

The Consultant will report directly to the World Bank Task Team Leader for Technical Assistance and will liaise with other World Bank colleagues working on transport, environment, disaster risk management and climate change issues in Kenya and worldwide.

This task team will provide technical advisory oversight, stakeholder engagement, and project management. The team will be available remotely or in person throughout for feedback, and in particular will commit to timely review of drafts as they become available.

If and when necessary, the Bank Task Team and the Consultant may agree to make adjustments to the task descriptions or the time frame for deliverables. The Consultant shall submit all deliverables in English language, and seek the Bank Task Manager's approval. All data collected shall be in standard open, ideally machine readable, formats. All data collected shall be in the format to be easily electronically transmitted to the client and will be considered public unless the client explicitly asks otherwise.

The World Bank Task Team will provide the list of key personnel in KeNHA and other relevant stakeholders. In KeNHA, key personnel with adequate technical background will be named a contact person(s) for this assignment. The contact person(s) will be responsible for providing relevant documents and data when requested by the Consultant and for being responsive to questions and requests for discussion by the Consultant. The Consultant is responsible to arrange their own office space and communication means for the desk work. The appointed entity will provide logistical support for preparation of the field visits.

Data Standards, Transfer Media and Licensing

Data formats and requirements:
All spatial data shall be usable by open source GIS programs.

Required skills/ experience

This technical assistance assignment will require the firm to staff an appropriate mix of highly qualified international and local staff. Where key experts proposed by firms do not have experience in Kenya, it is expected that they would be assisted by non-key experts with such experience. Team Leader will have overall responsibility for the direction, technical excellence and successful completion of the project and must have at least 15 years of Project Management experience having leadership qualities in addition to the requisite qualifications of one of the key staff positions noted below.

It is expected that the specialists among the team of consultants who will undertake this study will include:

(i) **Team leader/ Senior transport economist/planner** with a minimum of 15 years of international experience in transport planning (preferably regional),project prioritization and selection as well as climate adaptation in transport. Experience in dealing with uncertainty analysis would be a plus.
(ii) **Senior Disaster Risk Assessment Specialist/climate change specialist** with 10 years or more experience in the field of road engineering. Excellent knowledge of traffic management emergency response plans and protocols, CCA and/or DRM-related project experience preferred.
(iii) **Disaster Risk Modeller/flood risk modeller/landslide expert,** with at least 5 years of modelling experience in disaster risk.
(iv) **Senior economist/ trade and transport facilitation specialist** with 10 years of experience in statistical modelling. Experience on private sector and supply chains would be a plus.
(v) **Road and bridge engineer** with at least 10 years of international experience in road design and management.
(vi) **Geotechnical engineer** with at least 8 years of experience in analysis and application of environmental regulations and environmental and technical concepts.
(vii) **GIS/Mapping Specialist** with minimum of 5 years of GIS experience and experience working with various data formats such as CAD, GPS, etc. Knowledge of environmental resource management and transportation modelling.

Timeline and deliverables

The level of effort required from the Consultant is currently estimated at 8 months. In addition, the Consultant is expected to submit three hard copies and electronic copies in Word and PDF formats of each report in English.

Deliverables	Due date
Inception report. Present an overall approach and detailed program, work plan and completion schedule for the services, It shall discuss constraints and challenges identified by the Consultant and ways to address them in order to timely and effectively deliver the assignment.	1 month
Interim Report 1. The report shall present outputs from Task 1, namely Guidelines for climate change and natural hazard road network vulnerability and accompanying database.	2 months
Interim Report 2. The report shall present outputs from Task 2 and 3: For each critical link of the Corridors, delivered list of tested different strategies to increase the resilience of the network and definition of the most effective one based on the economic performance across a wide range of future conditions.	5 months
Interim Report 3 The Report will present outputs from Tasks 4&5:	6 months

Draft Final report The report shall include results from Tasks 1-5 as well as list of priority actions.	7 months
Final Report The Final Report shall address all previously received comments and on feedback from the all workshops.	8 months

Payment schedule

Deliverables	Percentage of contract price to be paid
Payment upon Contract Award	10%
Inception Report	10%
Interim Report 1	20%
Interim Reports 2 and 3	30 %
Draft and Final Reports	30%

Annex 3 Site Visit

COWI Denmark, has been contracted by World Bank to offer Technical assistance in increasing resilience of the Kenyan National roads. Their main objectives are:

i. To inform detailed design of the proposed improvements along Isiolo- Mandera road corridor to address natural hazards/projected climate related risks;
ii. To develop a methodology for assessing vulnerability of a national highway corridor to natural hazards/projected climate related risks and;
iii. To recommend institutional reforms needed (policy, institutional and operational level) to enhance capacity of KeNHA in the road network climate resilience planning.

To accomplish these objectives, Norken International Limited was subcontracted to carry out the base line study. This involved an assessment of the road network, and collection of other secondary data.

A field visit was conducted from Isiolo to Wajir, from 28th may 2018. The sections of roads investigated were as follows:

Road Name	New Road Class	Old Road Class	Road Length (KM)
Isiolo – Mandera			
Isiolo - JN B84	A10	B9	69.6
JNB84 – Modogashe	B84	B9	125.8
Modogashe – Wajir	A13	B9	156.4
Wajir - Rhamu	A13	B9	314.9
Rhamu – Mandera	A13	B9	76

The NETIP corridor traverses the counties of Isiolo, Meru, Wajir and Mandera. The road is generally gravelled. Roads within Isiolo town are tarmacked. The tarmac extends to about 8km to a police station called seventy eight along the NETIP corridor. From the police station, the gravel road proceeds to Wajir town, with drifts, culverts and bridges crossing at different locations. The roads within Wajir town are tarmacked to a radius of 25km. The gravel road from Wajir to Elwak is dominated with long sections of sand deposits along the road. From Elwak towards Rhamu, the road is tarmacked to about 12km, to a centre called corner S. The road from Elwak to Rhamu is under construction to bitumen standards. The construction is funded by the ministry of defence. There section from Wargadud to Rhamu (a section of about 35km) is also tarmacked. The road from Rhamu to Mandera is generally gravelled and is seriously undermined by the storm water. The roads within Mandera town are tarmacked and in good condition.

Of the total length of corridor investigated, the section between Wajir and Elwak proved to be the most challenging in terms of security, due to its proximity to the Somali border. Fewer photos were therefore taken at these section, since the security agencies advised the team to drive at high speeds along these sections and also have minimum number of stops.

Nevertheless, a comprehensive study was undertaken of the NETIP corridor, and the following photos were put together indicating the main hazard areas along the corridor. The photos taken were geo referenced to indicate the position and direction on which the photo was taken.

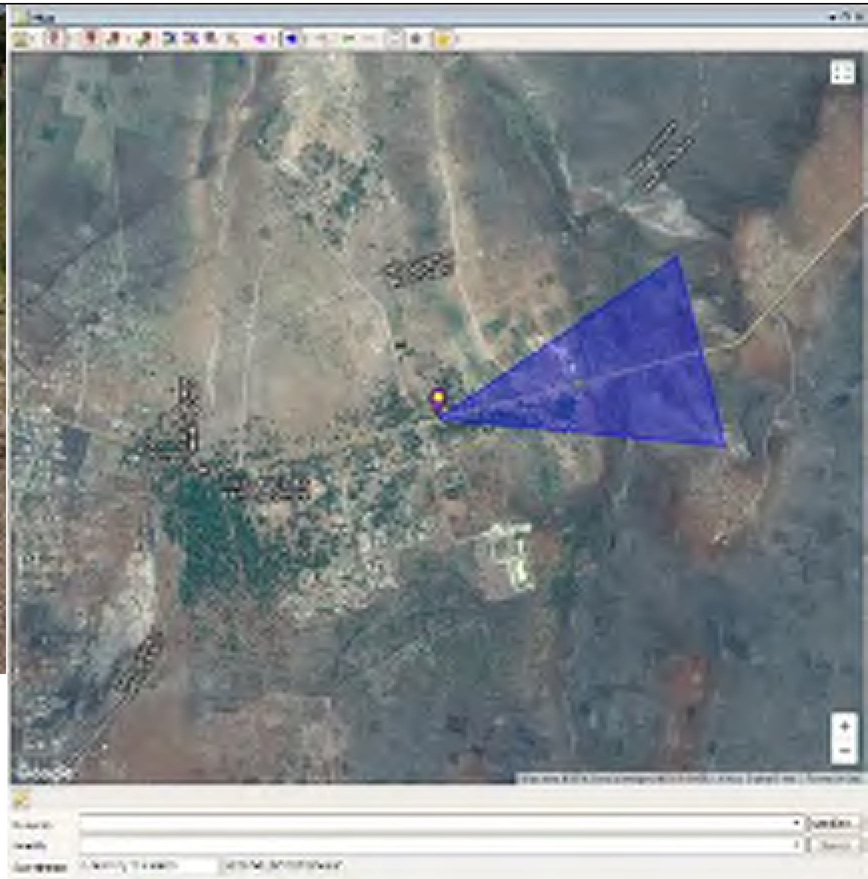
The taking of photos began about 8km to the east of Isiolo town, where the tarmacked section terminates near seventy eight police station.

Description: End of tarmac road, about 8km from Isiolo town at 78 police station, and beginning of the gravel road to Wajir

Coordinates: N0°21'45.78" E37°37'4.81"

Altitude 1059.0m

Point 1



Description: Gravel road towards Habaswein.
Coordinates: N0°21'45.78" E37°37'4.81"

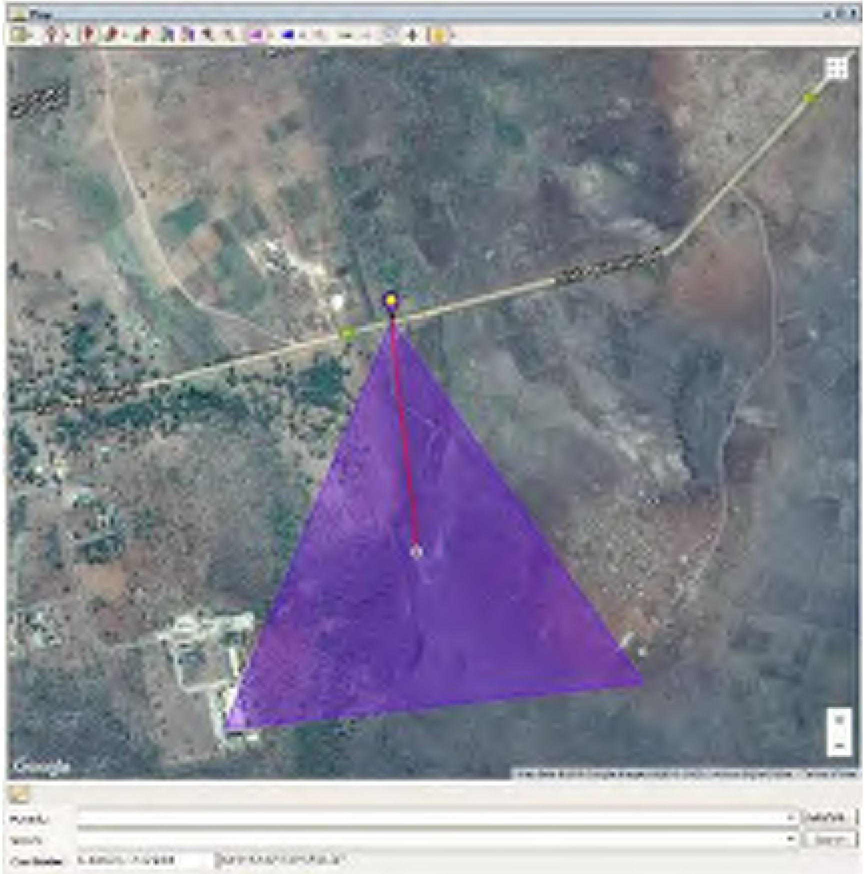
Altitude: 1062.0m

Point 1

From Isiolo town, the tarmac ends at around 8km distance at seventy eight police station. The road is well maintained by a contractor on site carrying out the periodic and emergency maintenance. The land in the area is generally flat.

Description: Upstream channel of a 900mm diameter pipe culvert.
Coordinates: N0°21'52.82" E37°37'32.50"
Altitude: 1070.8 m

Point 2



Description: Inlet of the 900mm pipe culvert with no signs of siltation or overtopping.
Coordinates: N0°21'52.56" E37°37'32.55"
Altitude: 1059.0m

Point 2

Description: Approach to a cross culvert under repair, from washouts of previous rains. With the photo taken in the forward direction.
Coordinates: N0°21'52.56" E37°37'32.50"
Altitude: 1082.7m

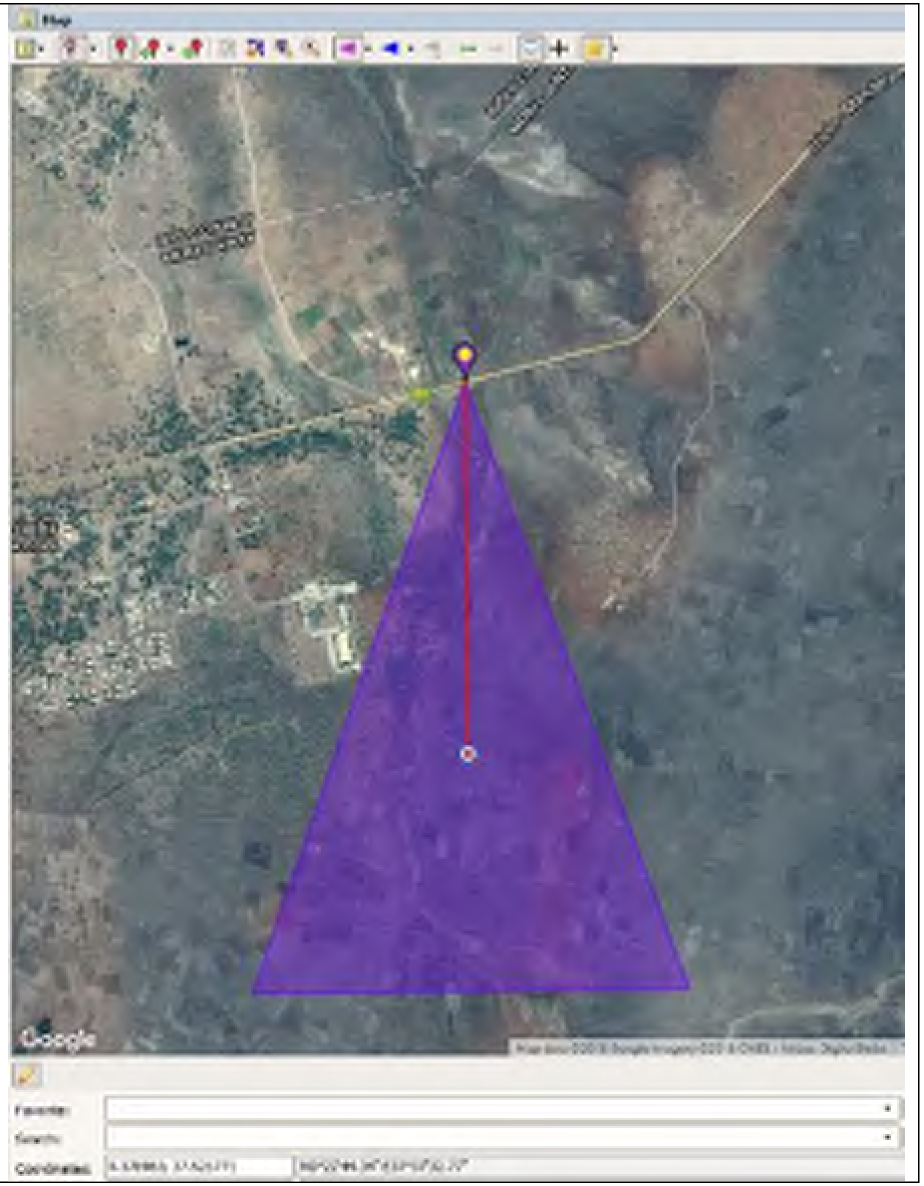
Point 2

Description: Repair of washed out culvert, after the heavy rains. Photo taken on the lhs
Coordinates: N0°21'53.03" E37°37'34.31"
Altitude: 1049.0m

Point 2

Description: Outlet of the culvert under repair. Repair of washed out culvert, with photo taken on the rhs.
Coordinates: N0°21'53.03" E37°37'34.31"
Altitude: 1049.0 m

Point 2



Description: 900mm diameter cross culver, which is Silted. The information obtained from the locals is that the culvert overtops during the wet season.
Coordinates: N0°21'53.34" E37°37'35.53"
Altitude: 1052.0 m a.s.l

Point 2

Description: Outlet of the 900mm diameter silted cross culvert, with photo taken on the lhs
Coordinates: N0°21'53.34" E37°37'35.53"
Altitude: 1052.0 m

Point 2

At this section, there are three 900mm diameter pipe cross culverts around 50m from each other at a low area. The first culvert is ok with no signs of siltation or overtopping. The second culvert at the lowest point experienced washout from the previous rains and is being repaired by a contractor on site. The last culvert is silted. The culvert under repair has history of being washed out every rainy season, indicating that the discharge at this section exceeds the size of the culvert.

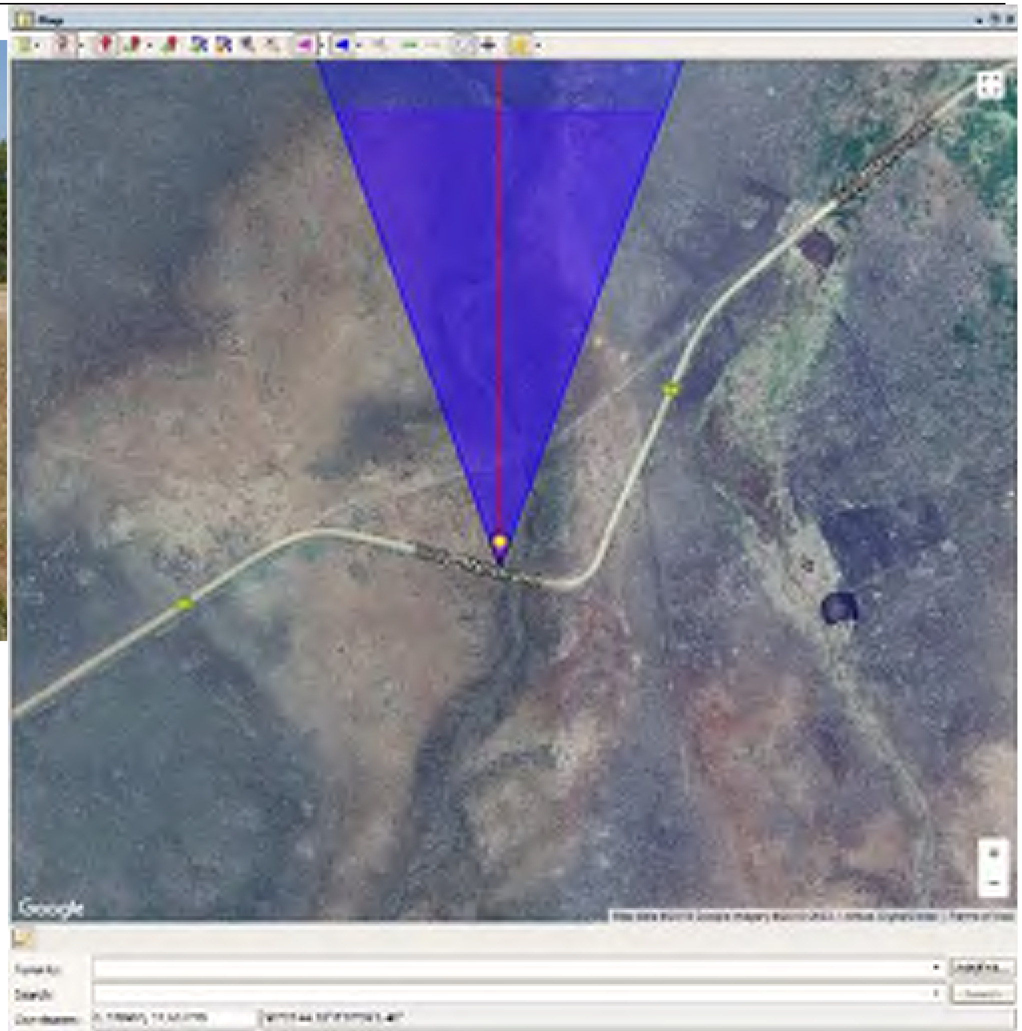
Description: Gravelled road maintained by KeNHA Upper Eastern Region under the routine maintenance program. Approach to a bridge
Coordinates: N0°22'45.66" E37°39'1.52"

Altitude: 1033.0 m

Point 3

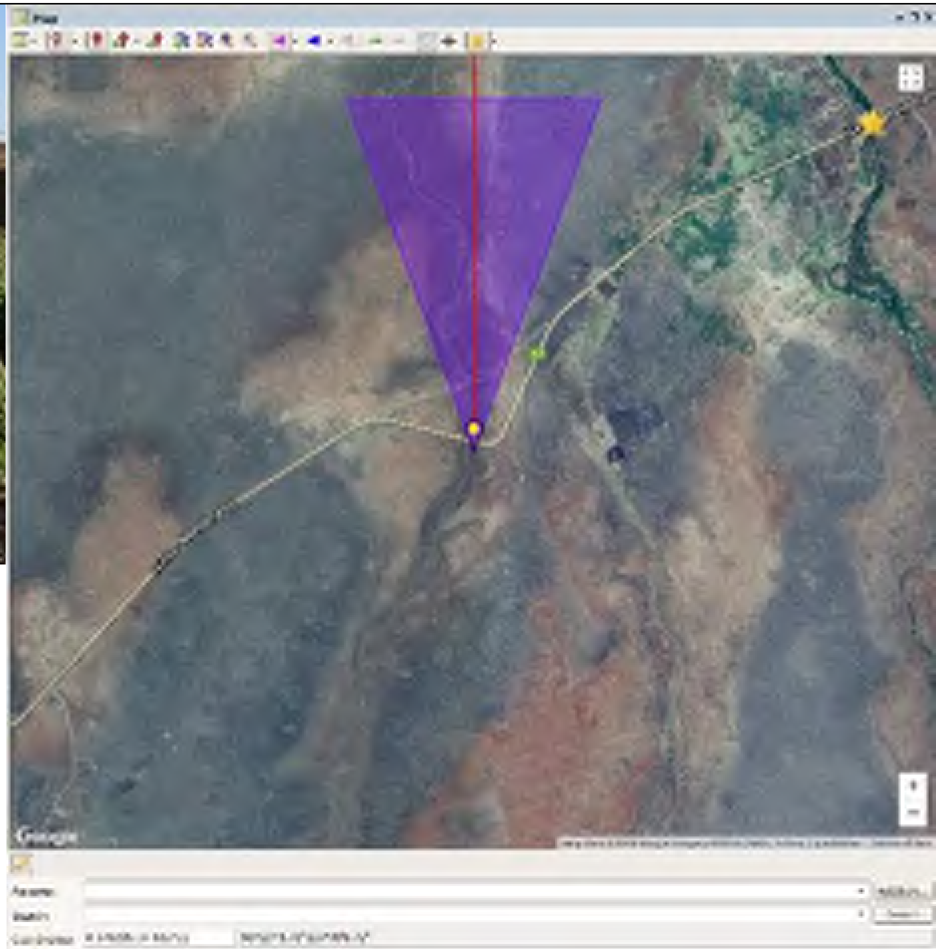
Description: Bridge section approximately 35m long x 6m wide. Dry river bed with no signs overtopping experienced.
Coordinates: N0°22'44.35" E37°39'6.40"
Altitude: 1047.0m

Point 3



Description: Bridge piers on the dry riverbed with a depth of approximately 3m.
Coordinates: N0°22'41.72" E37°39'8.72"
Altitude: 1047.0m

Point 3

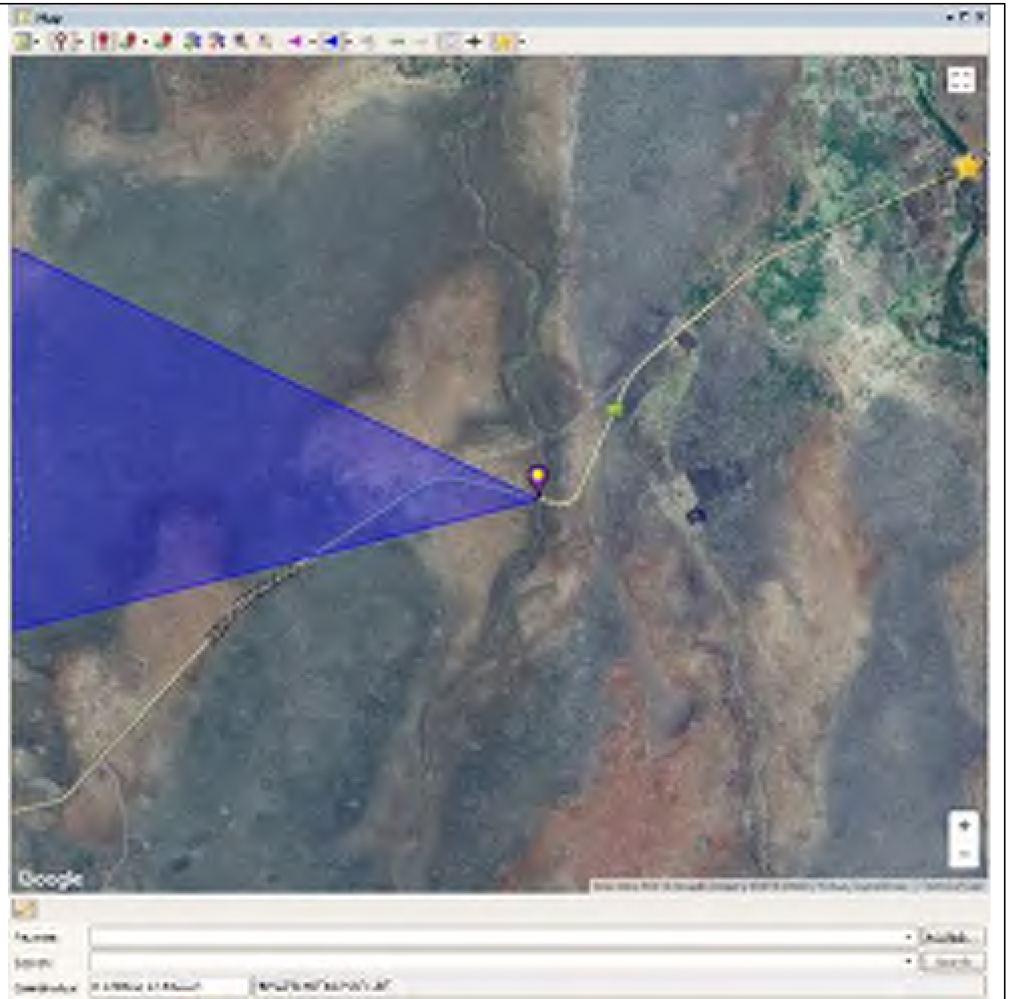


Description: Dry river bed downstream on the lhs with scouring to expose rock at the bottom. Scouring is about 1m deep.
Coordinates: N0°22'41.72" E37°39'8.72"
Altitude: 1047.0m

Point 3

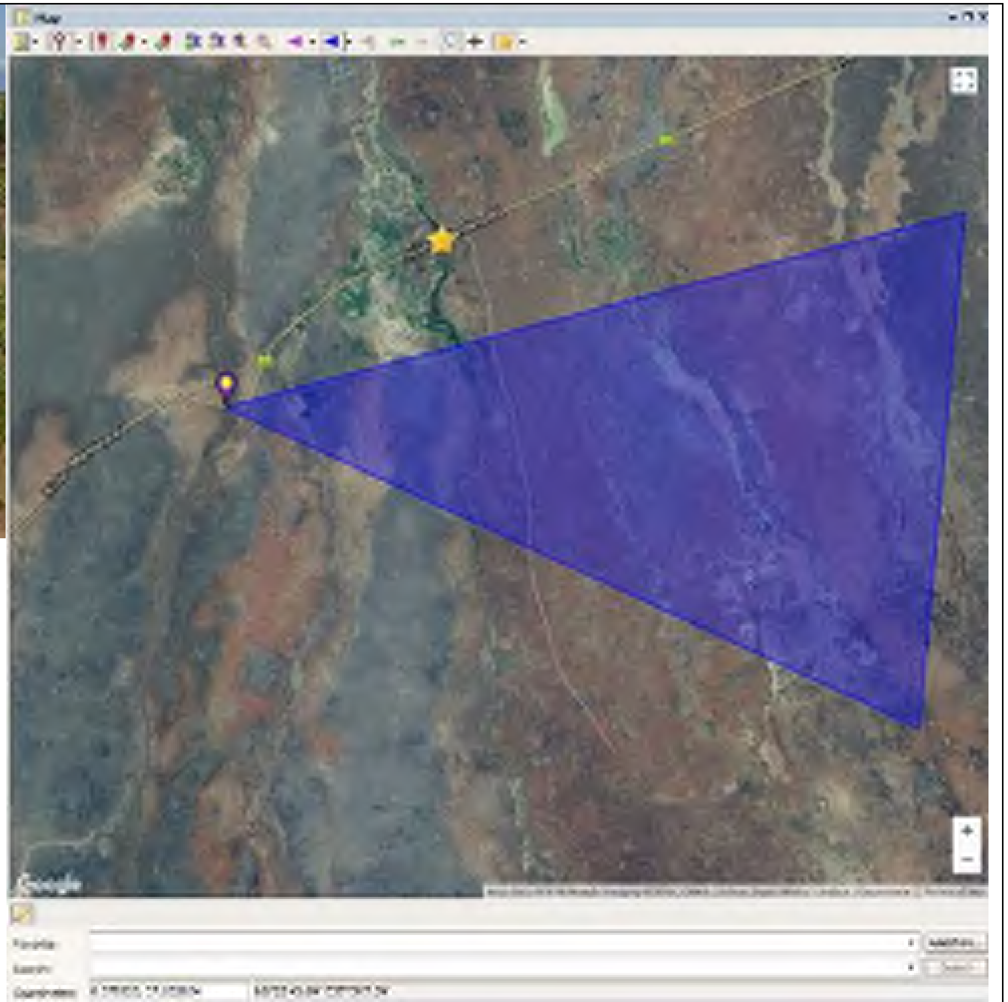
Description: 6m wide Bridge deck with no guard rails on the side.
Coordinates: N0°22'43.69" E37°39'7.29"
Altitude: 1047.0m

Point 3



Description: Forward view of the approach road to the bridge.
Coordinates: N0°22'43.69" E37°39'7.29"
Altitude: 1056.0m

Point 3

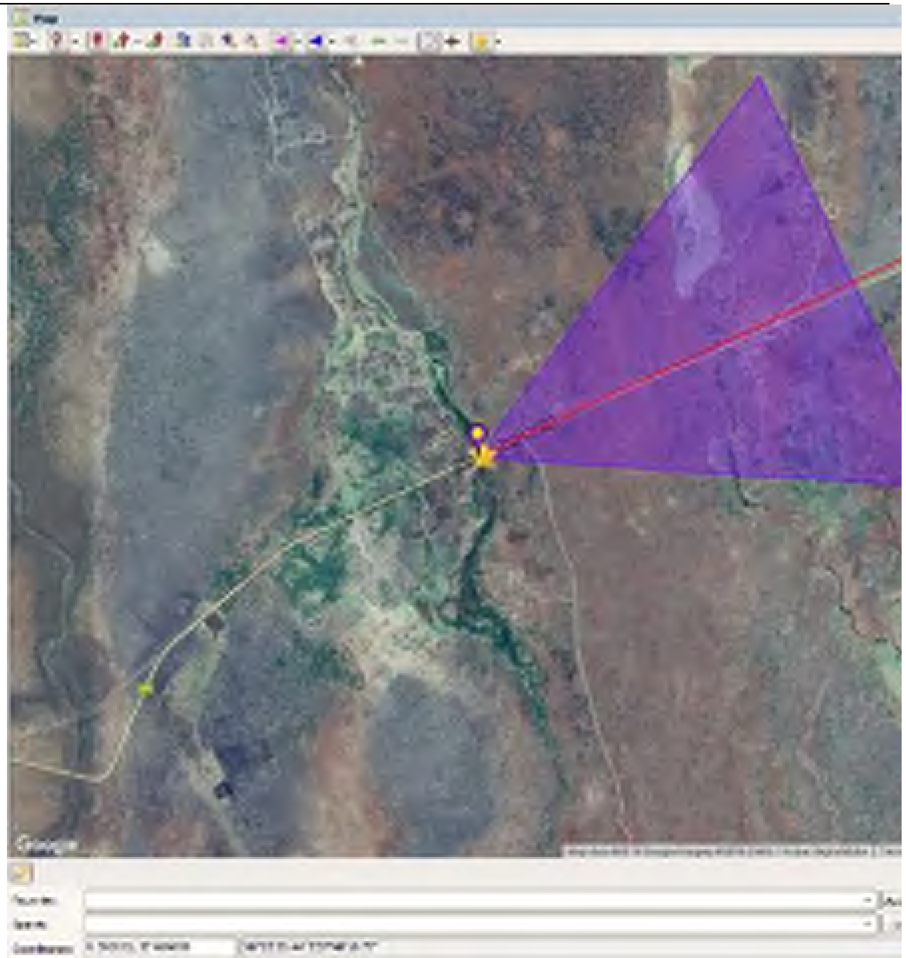


At this section there is a narrow bridge with no guard rails installed. The deep scouring is an indication of a lot of discharge at high speeds during the wet season. The bridge shows no signs of overtopping.

Description: Forward view. Approach to a box culvert location.
Coordinates: N0°23'33.44" E37°40'10.77"

Altitude: 1049.0 m

Point 4



Description: Low Swampy area on the culvert upstream on the rhs.
Coordinates: N0°23'33.73" E37°40'11.66"

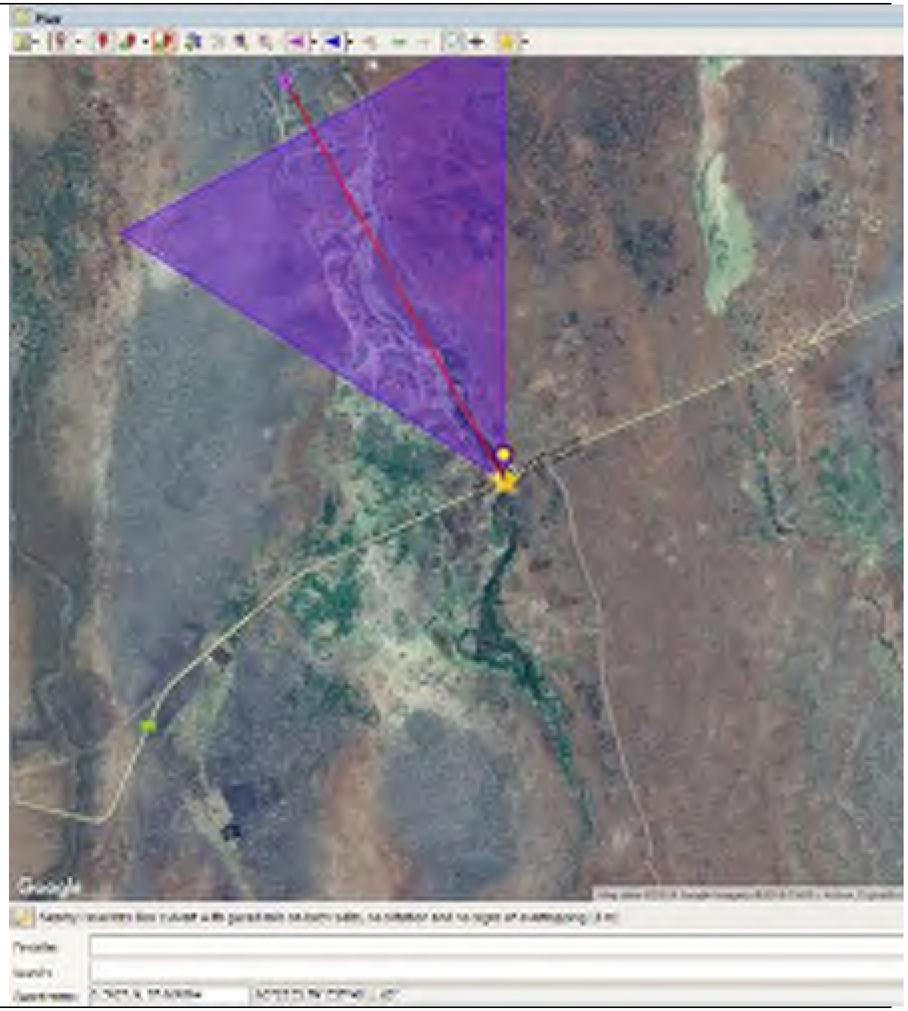
Altitude: 1048.9 m

Point 4

Description: Low Swampy area on the culvert downstream on the lhs.
Coordinates: N0°23'33.79" E37°40'11.62"

Altitude: 1046.9m

Point 4



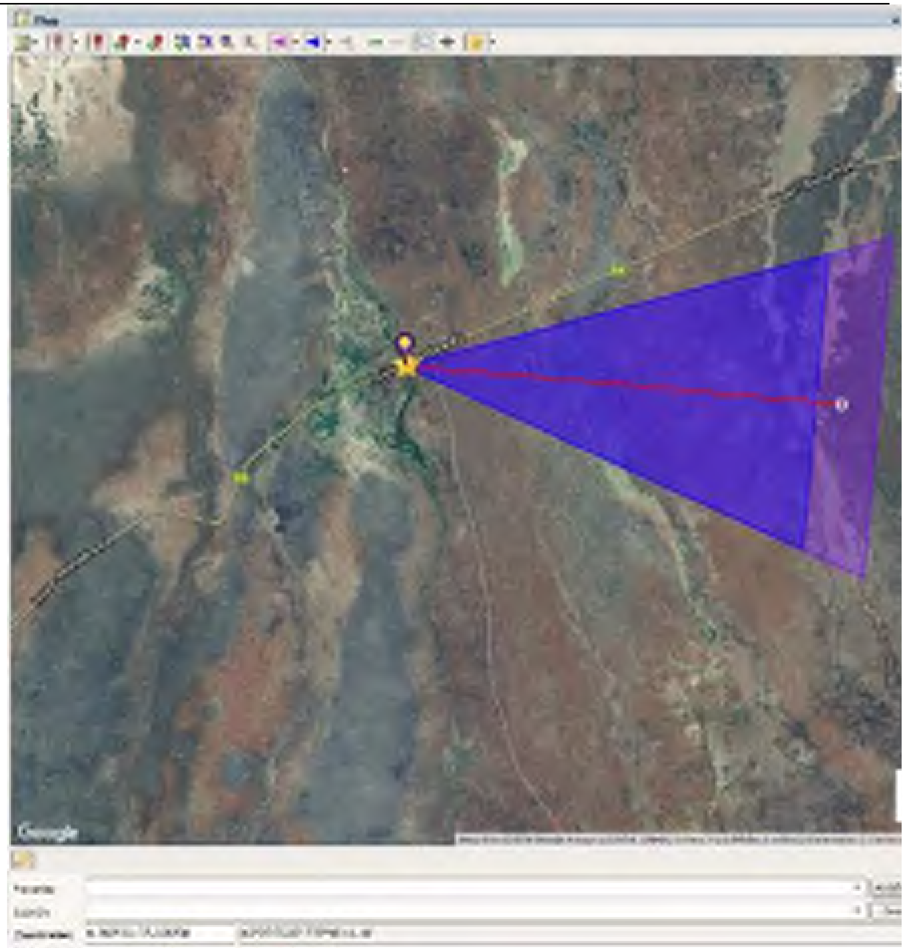
Description: Panoramic view of the multiple culvert crossing on the lhs. With guard rails
Flat area with 2 twin box culverts (3m x 2m), 1 twin circula culvert 600mm diameter and 2 circular culverts of 900mm diameter.
Coordinates: N0°23'34.70" E37°40'12.36"

Altitude: 1050.4 m

Point 4

Description: Downstream, lhs view of the multiple culvert crossing. The downstream section has scouring of about 2m at the box culvert outlet.
Coordinates: N0°23'33.02" E37°40'11.10"
Altitude: 1054.0m

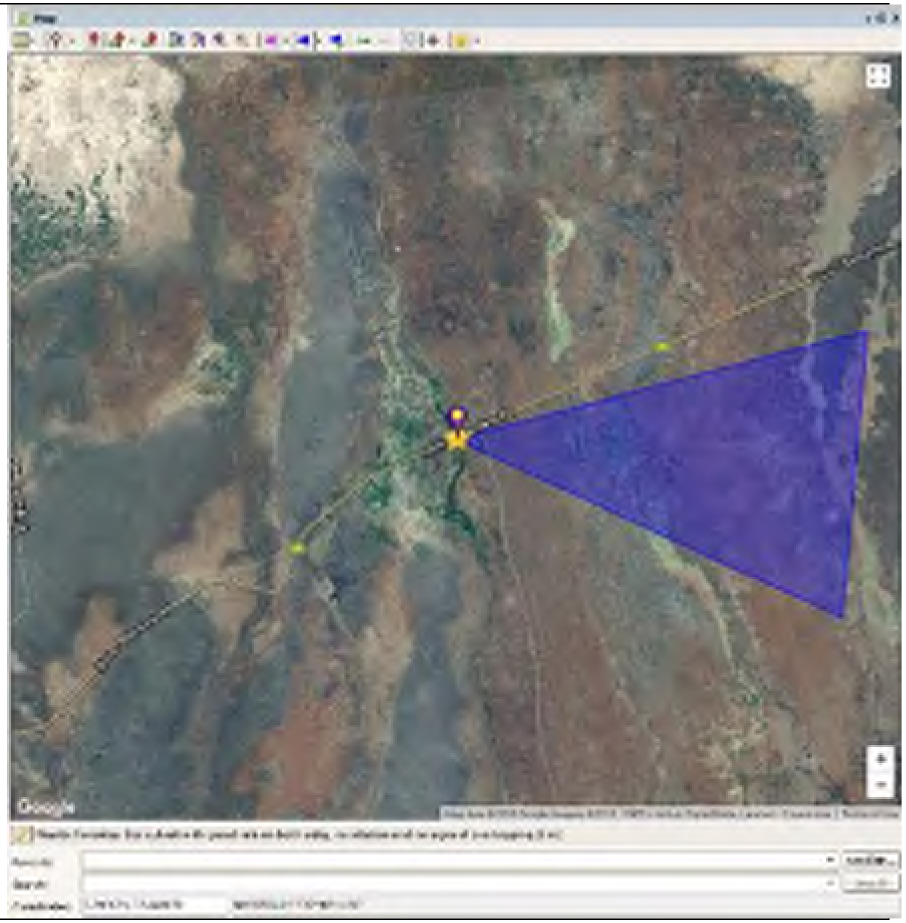
Point 4



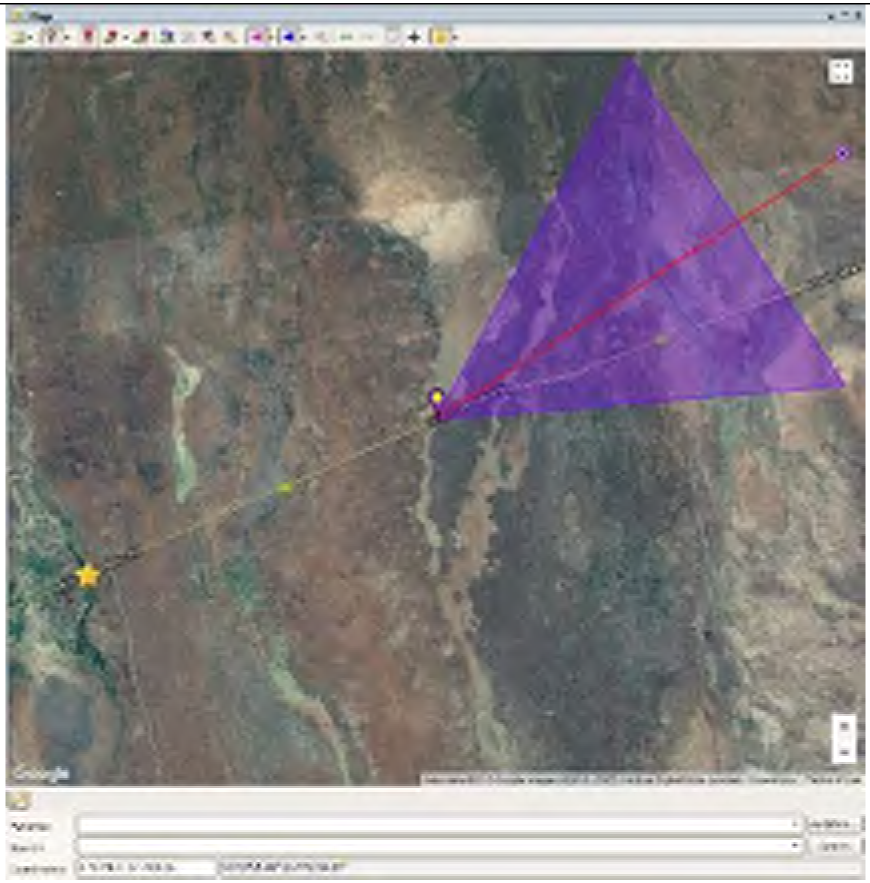
Description: Forward view of the approach at the multiple culvert crossing, with guard rails on both sides.
Coordinates: N0°23'33.61" E37°40'11.56"

Altitude: 1011.0m

Point 4



At this section the water crosses at a wide section around 60m. The crossing comprises of two twin box culverts 3m x 2m, about 15m from each other. There are also two 900mm diameter and one 600mm twin culvert crossings. The inlet shows no signs of scouring but at the outlet there is scouring of around 2m at the box culvert outlet.



Description: Forward view of the approach to the 900mm diameter twin pipe culvert crossing

Coordinates: N0°24'26.88" E37°42'10.89"

Altitude: 1050.4m

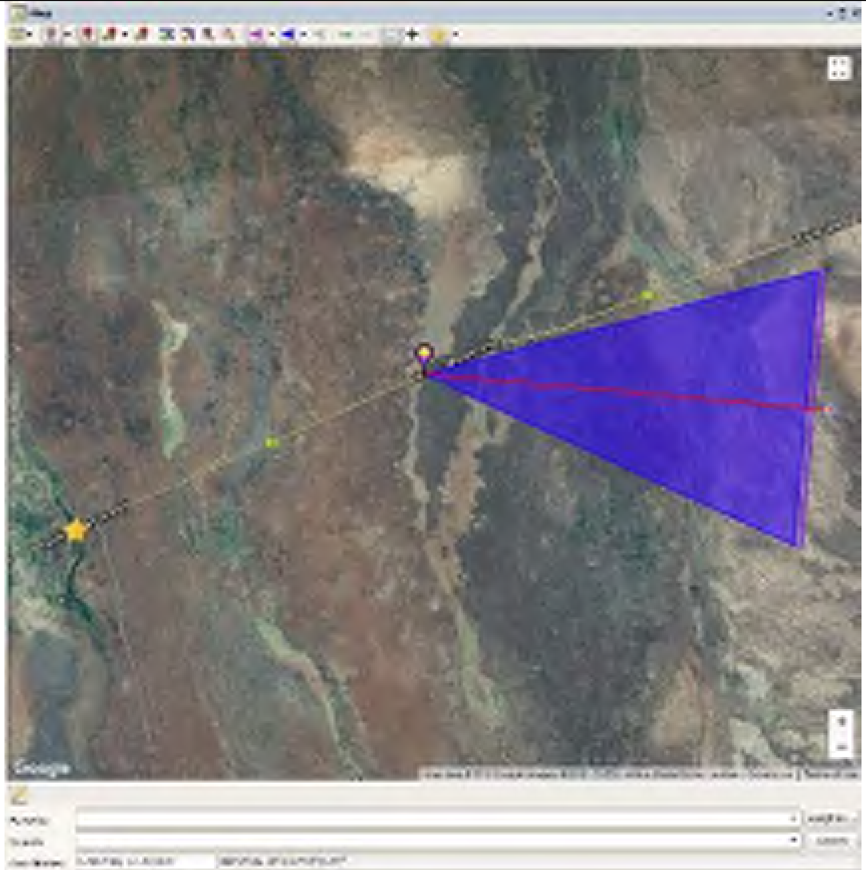
Point 5

Description: Scoured outlet on the lhs of a 900mm twin culvert crossing. Scouring is about 0.5m

Coordinates: N0°24'26.78" E37°42'10.91"

Altitude: 1014.0m

Point 5

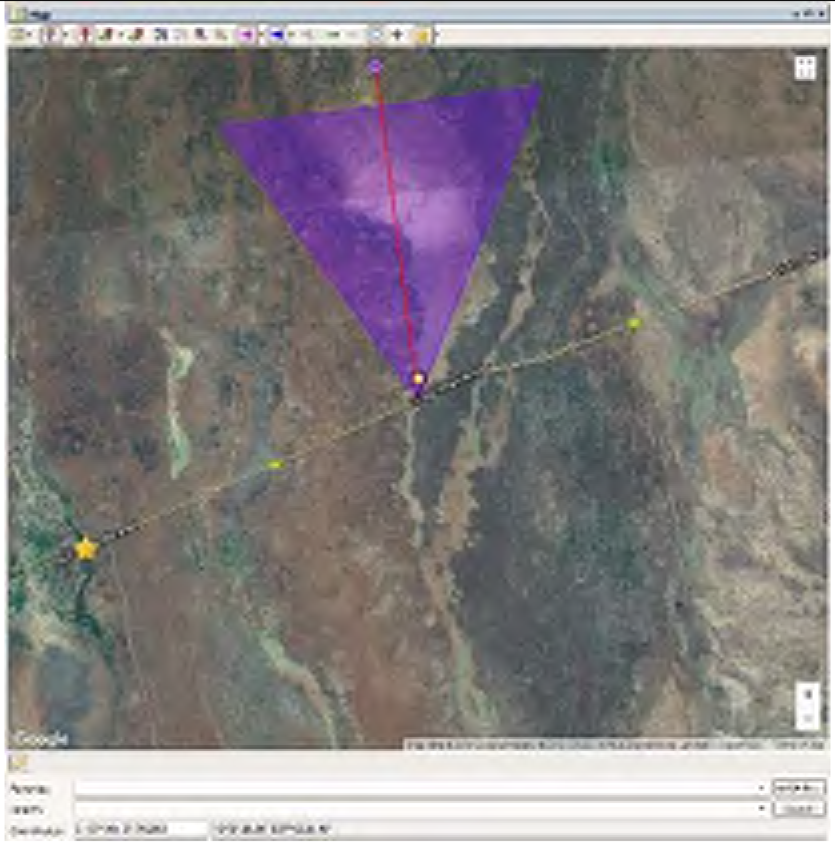


Description: Downstream channel on the lhs of a 900mm twin culvert crossing, with signs of scouring to a depth of around 0.5m

Coordinates: N0°24'26.66" E37°42'10.40"

Altitude: 1052.0m

Point 5

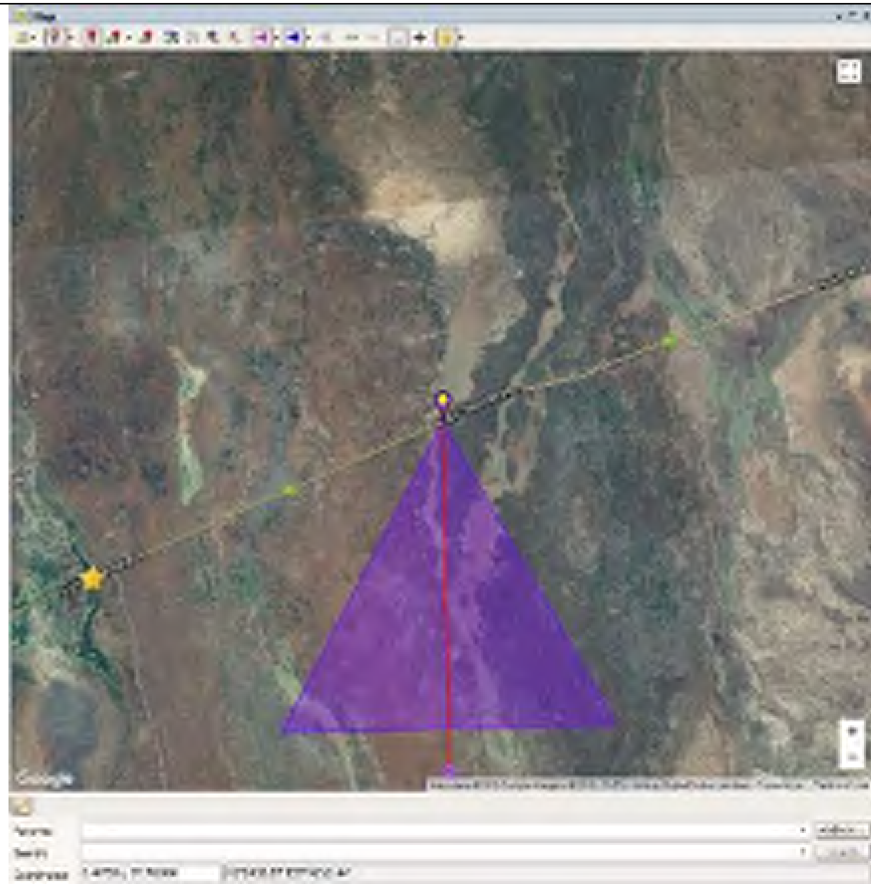


Description: Upstream channel on the rhs of a 900mm twin culvert crossing

Coordinates: N0°24'26.57" E37°42'10.44"

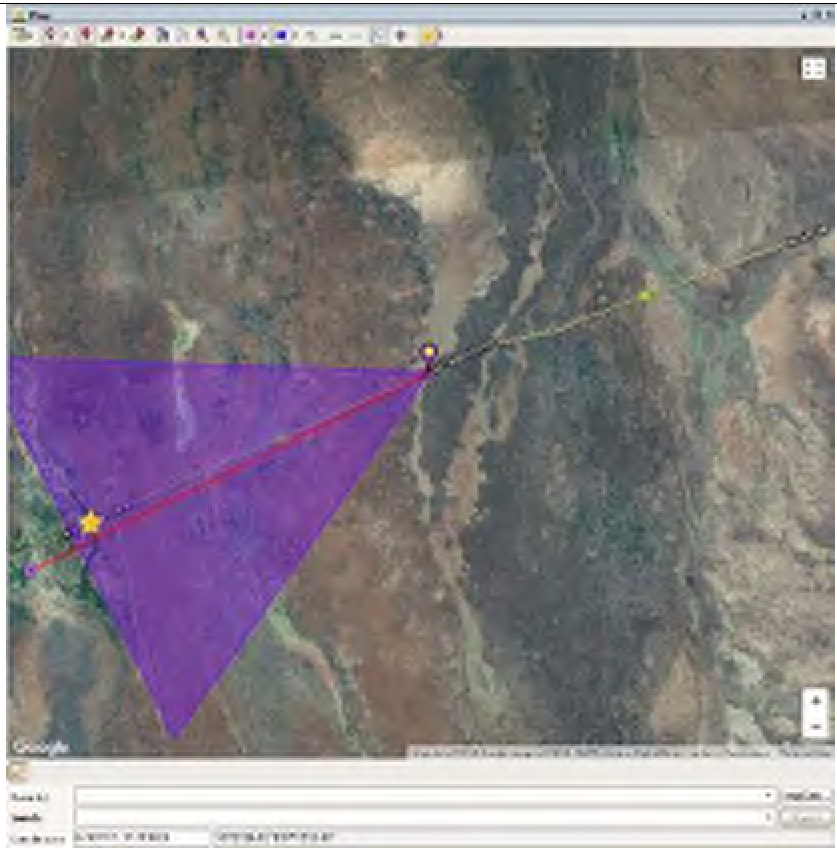
Altitude: 1047.3m

Point 5



Description: Backward view of the approach to the 900mm diameter twin pipe culvert crossing
Coordinates: N0°24'26.81" E37°42'10.89"
Altitude: 1059.6m

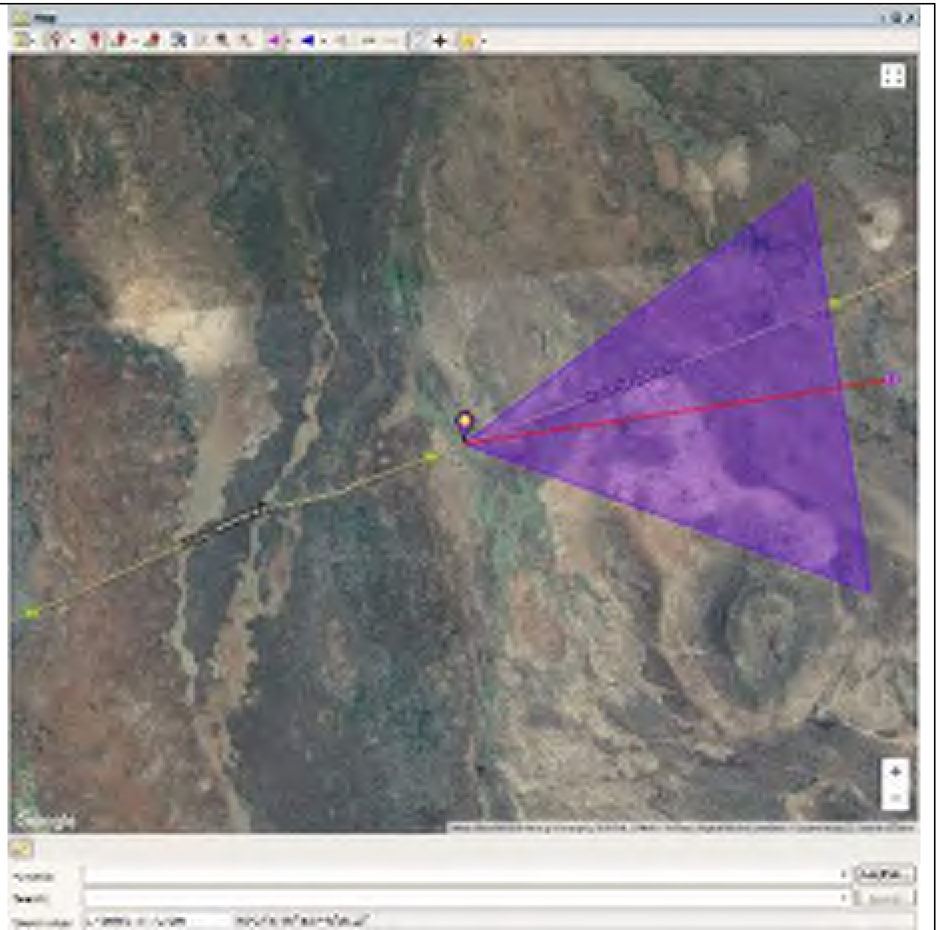
Point 5



The 900mm twin cross culvert is at a generally flat area, with no signs of high discharge, since the channel has no serious scouring.

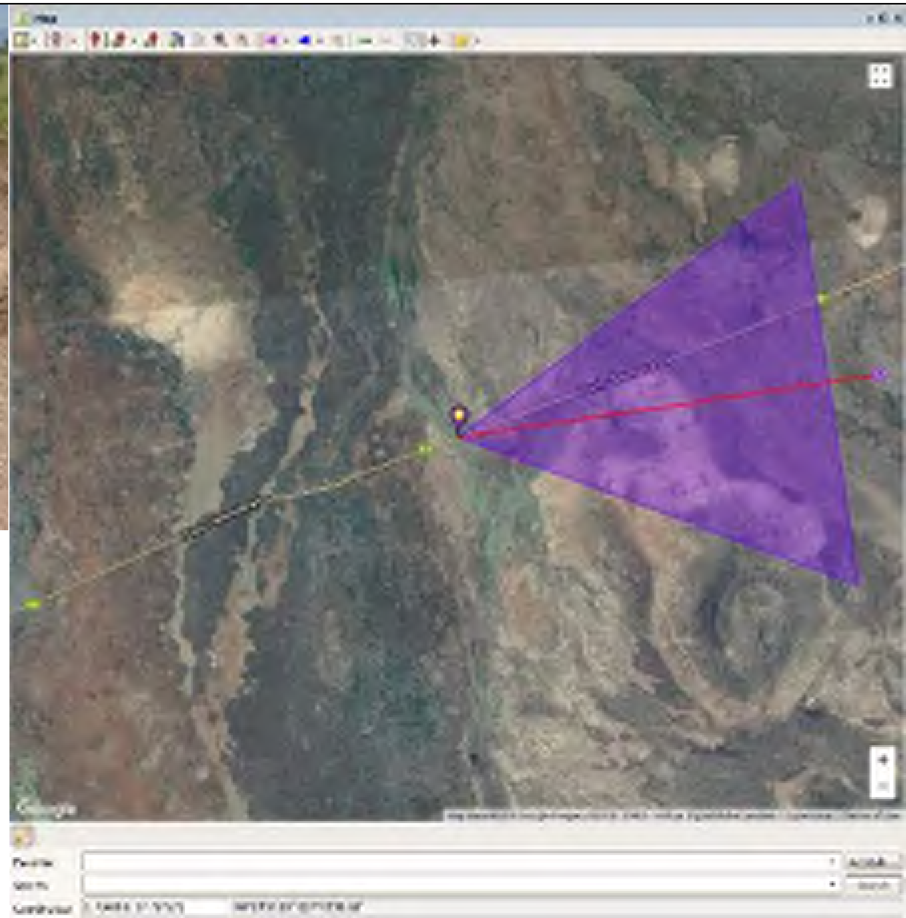
Description: Forward view to a crossing with no structure.
Coordinates: N0°24'57.25" E37°43'37.01"
Altitude: 1038.0m

Point 6



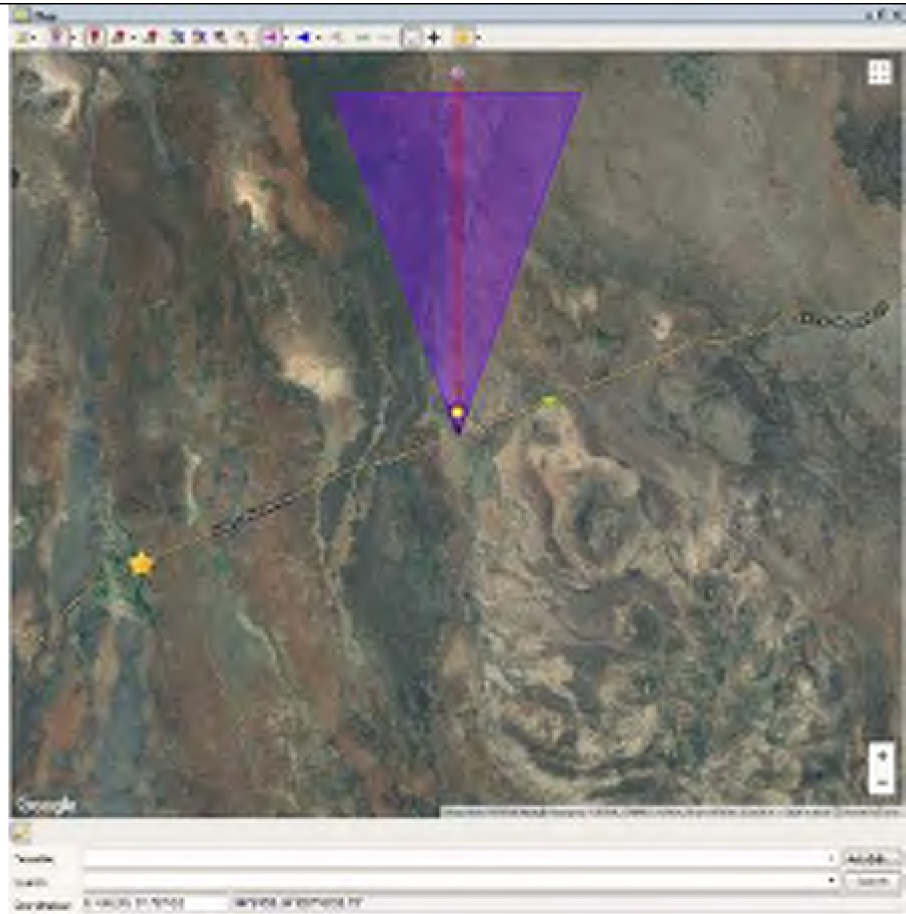
Description: Forward view of a damaged section at a water crossing without a drainage structure.
Coordinates: N0°24'57.25" E37°43'37.01"
Altitude: 1032.7m

Point 6



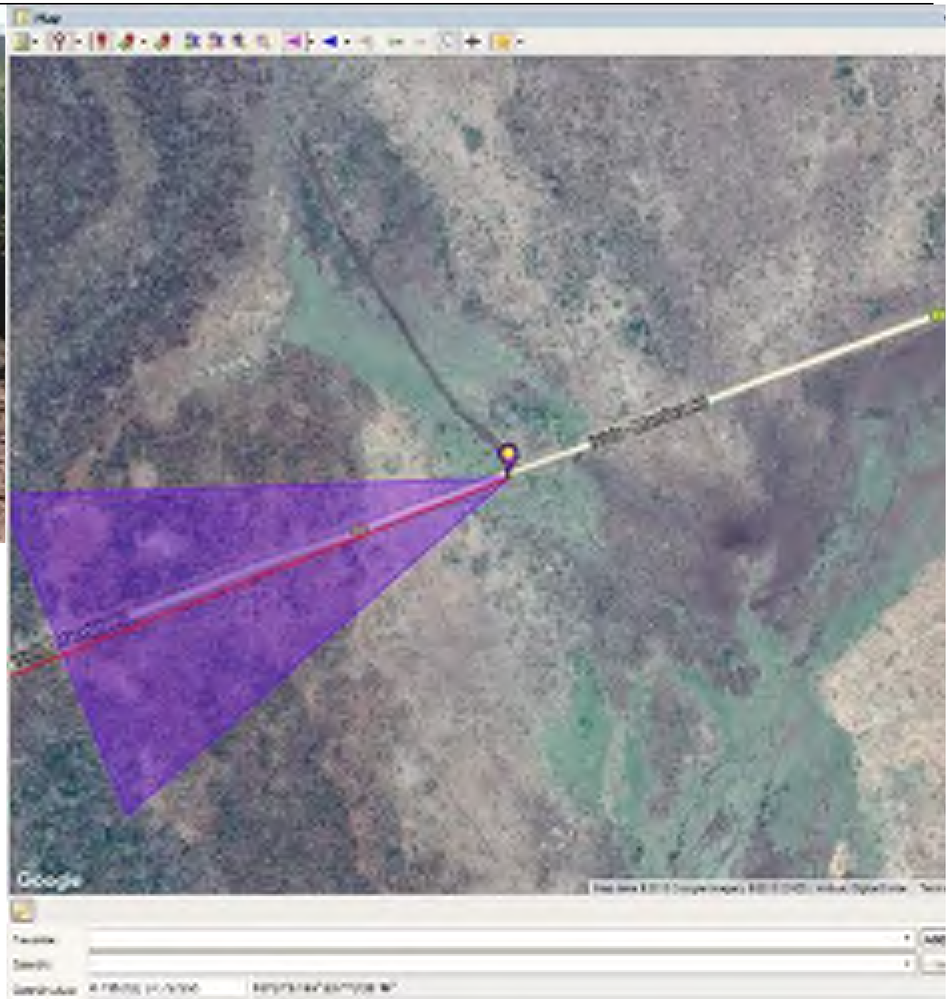
Description: Downstream of the water crossing on the lhs, at a section with no structure, Scouring to a depth of around 1.5m
Coordinates: N0°24'58.10" E37°43'38.75"
Altitude: 1025.0m

Point 6



Description: Backward view of a damaged section at a water crossing without a drainage structure.
Coordinates: N0°24'57.65" E37°43'38.46"
Altitude: 998.0m

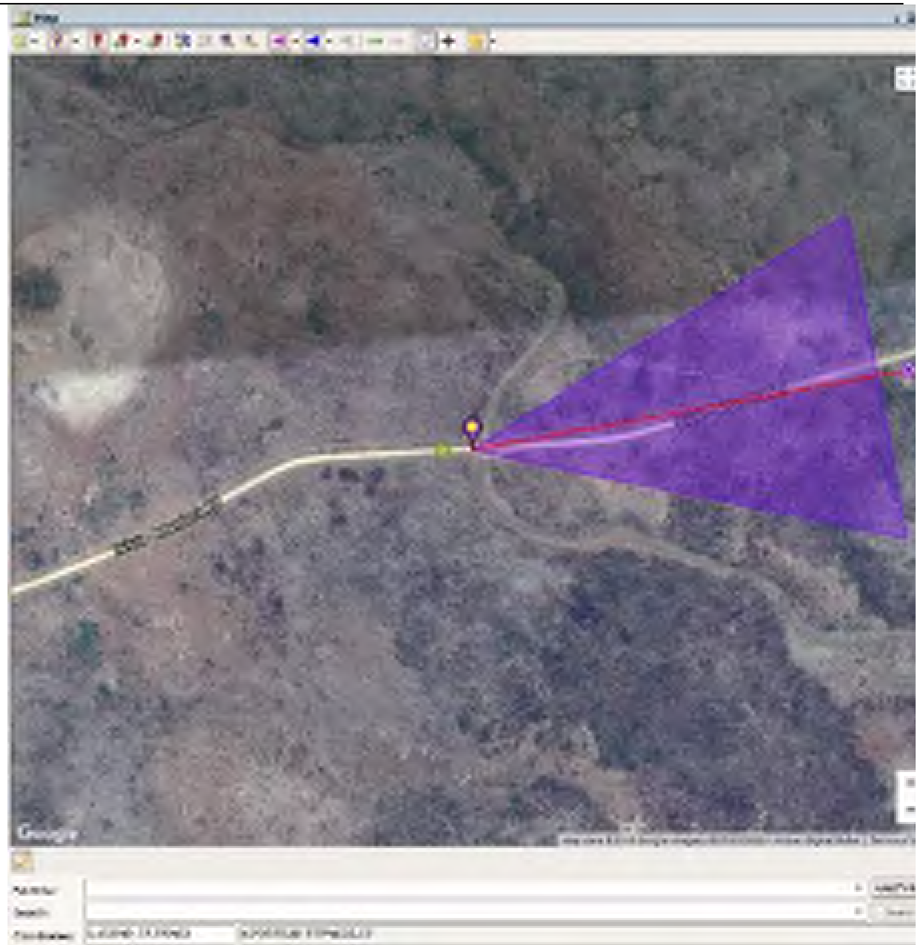
Point 6



Rain water has scoured into the road surface, at a crossing with no drainage structure, at the area near the Rapid Deployment Unit. The section requires a culvert or drift crossing.

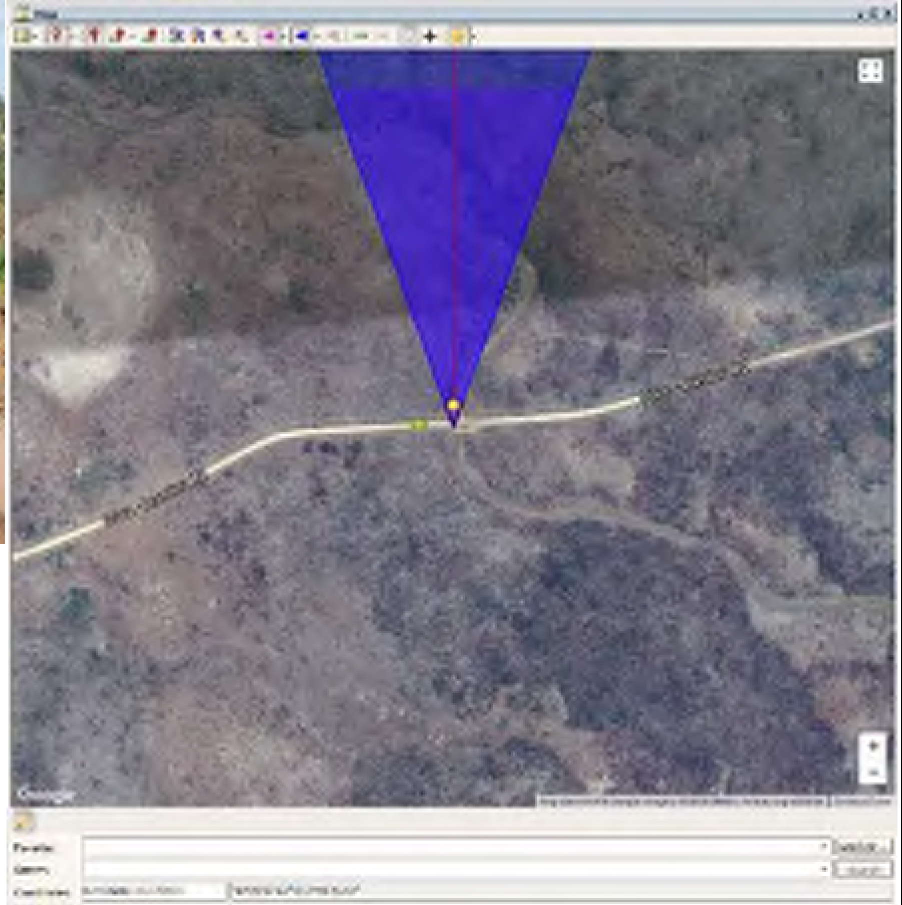
Description: Forward view to a triple box culvert location at a flat area.
Coordinates: N0°24'57.65" E37°43'38.46"
Altitude: 998.0m

Point 7



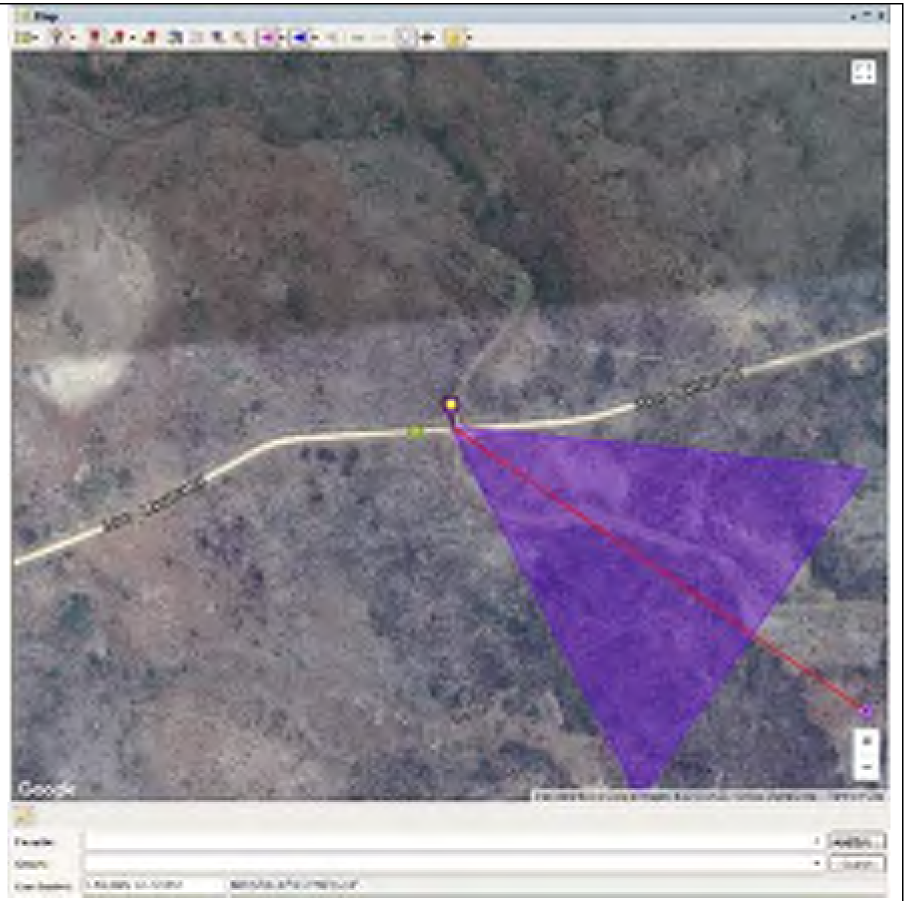
Description: Rhs view to a 4m x 2m triple box culvert inlet location with no signs of overtopping.
Coordinates: N0°25'57.67" E37°46'23.17"
Altitude: 1055.0m

Point 7



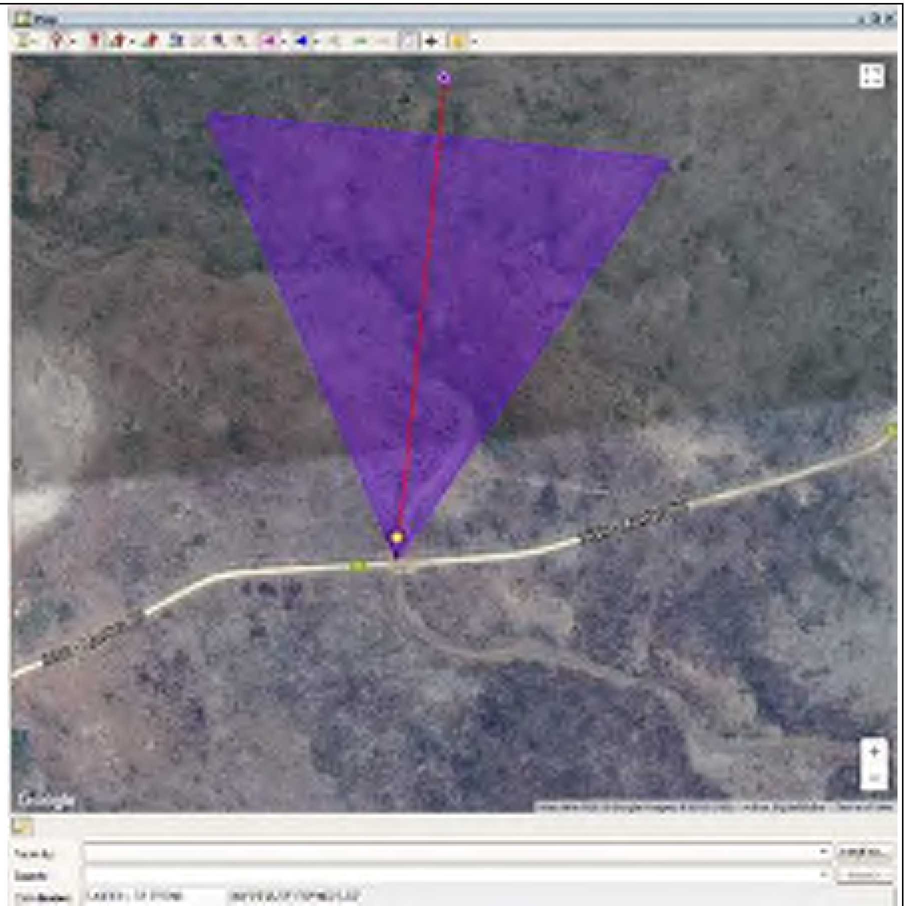
Description: Protection works at the triple culvert outlet on the lhs.
Coordinates: N0°25'58.33" E37°46'23.33"
Altitude: 1053.1m

Point 7



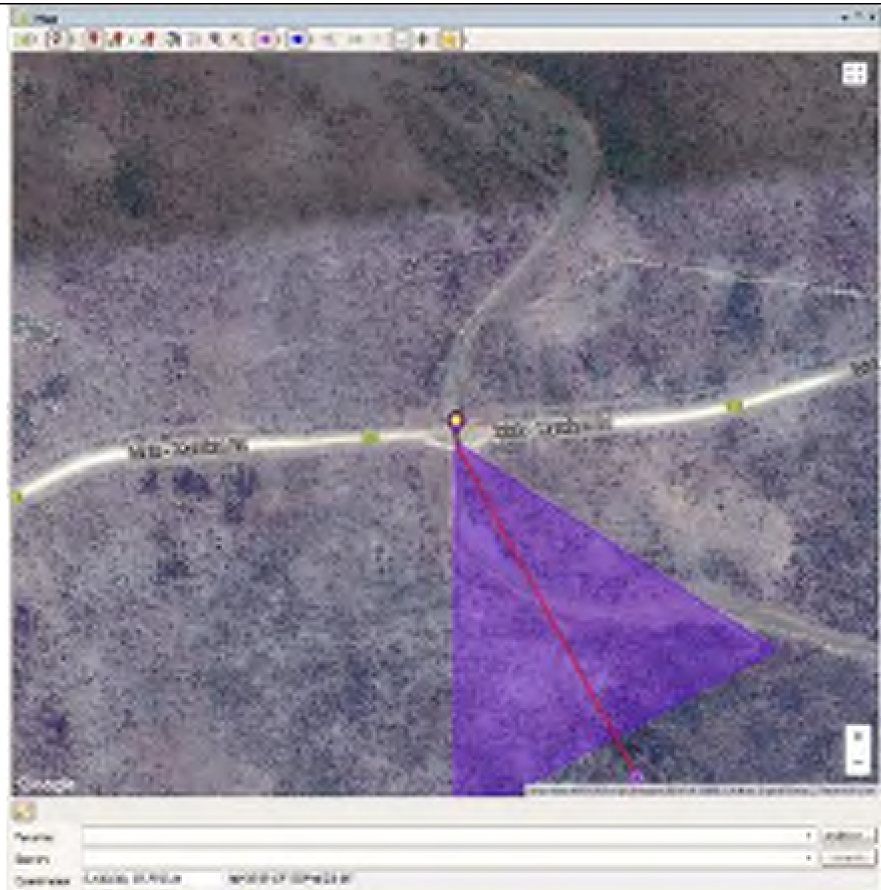
Description: Downstream channel scoured to expose the rock on the lhs.
Coordinates: N0°25'58.37" E37°46'23.55"
Altitude: 1058.4m

Point 7



Description: Upstream channel with a drift diversion.
Coordinates: N0°25'57.67" E37°46'23.95"
Altitude: 1064.7m

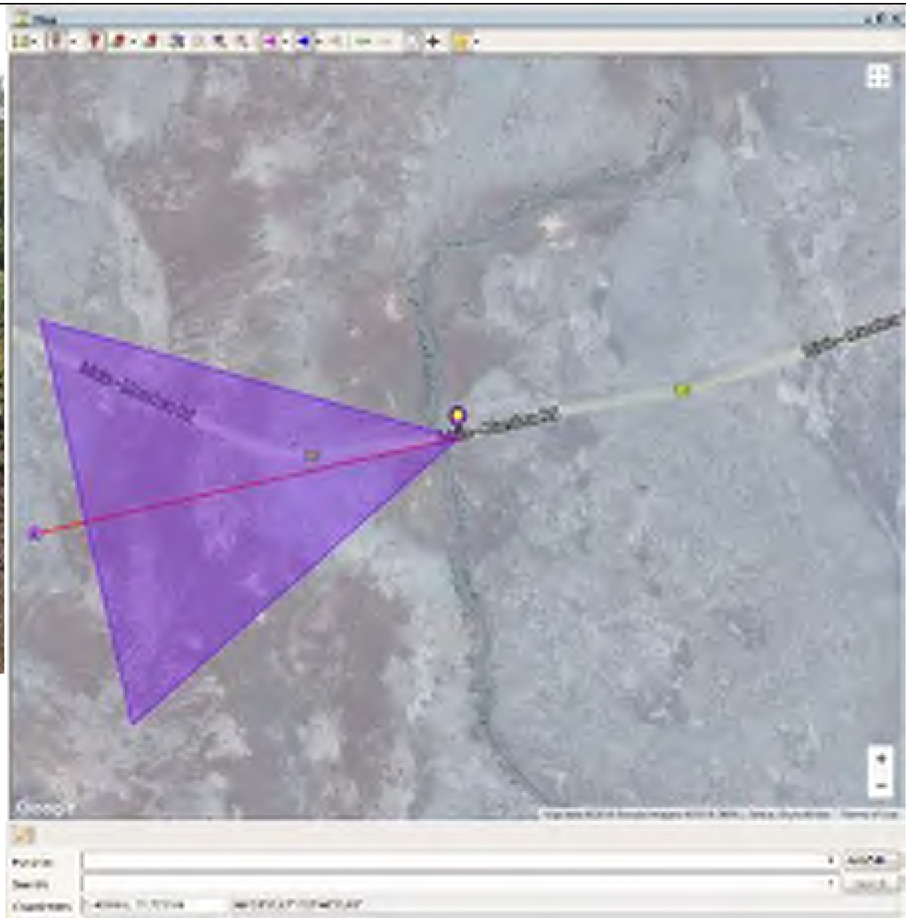
Point 7



At the triple box culvert, the channel is wide and scoured indicating a lot of discharge during the wet season. The gabions on the outlet has provided a suitable protection to the slope of the road and scouring is only evident at the bottom of the outlet.

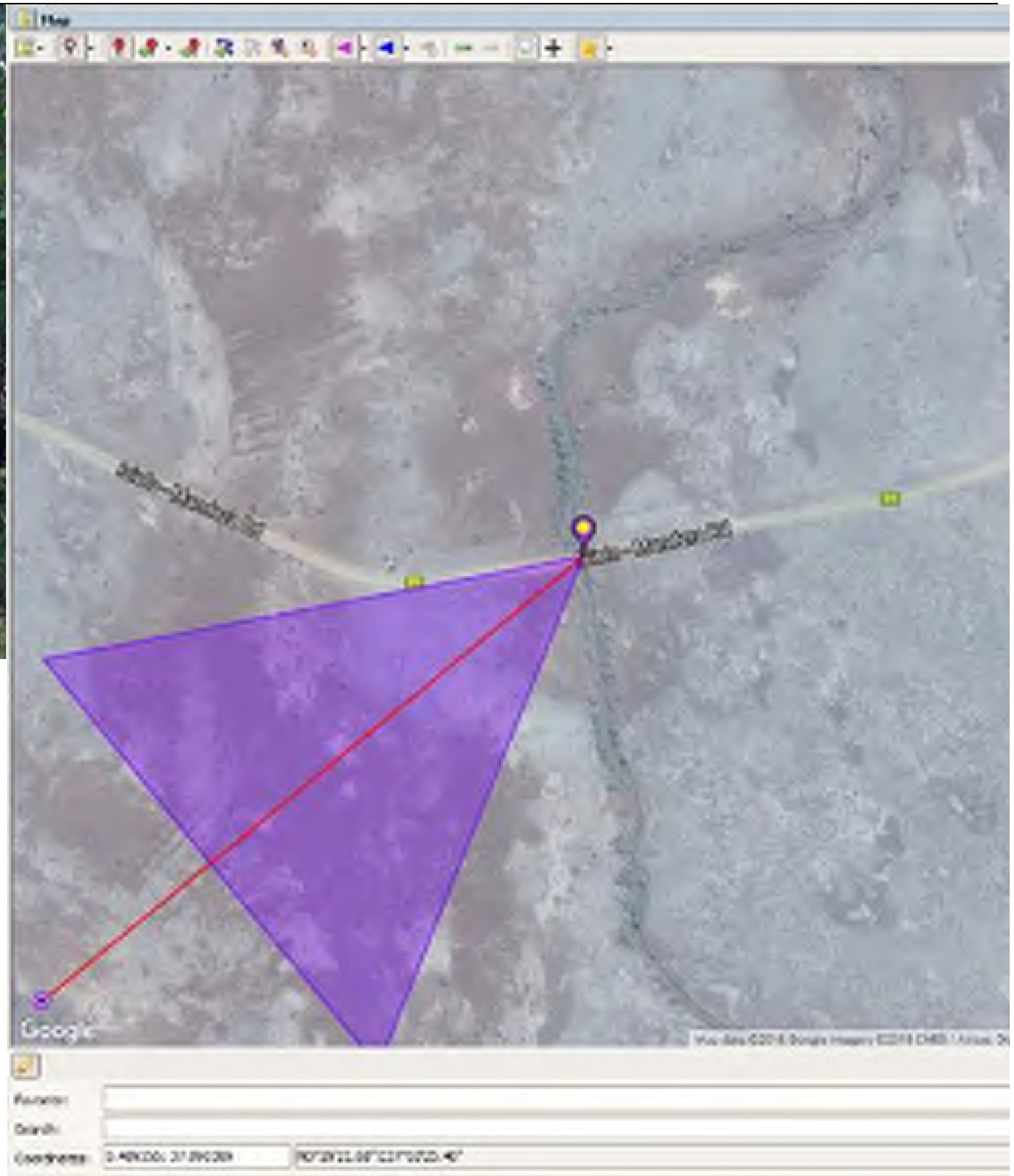
Description: Backward view, approach to a vented drift.
Coordinates: N0°29'21.56" E37°53'25.96"
Altitude: 1032.9m

Point 8



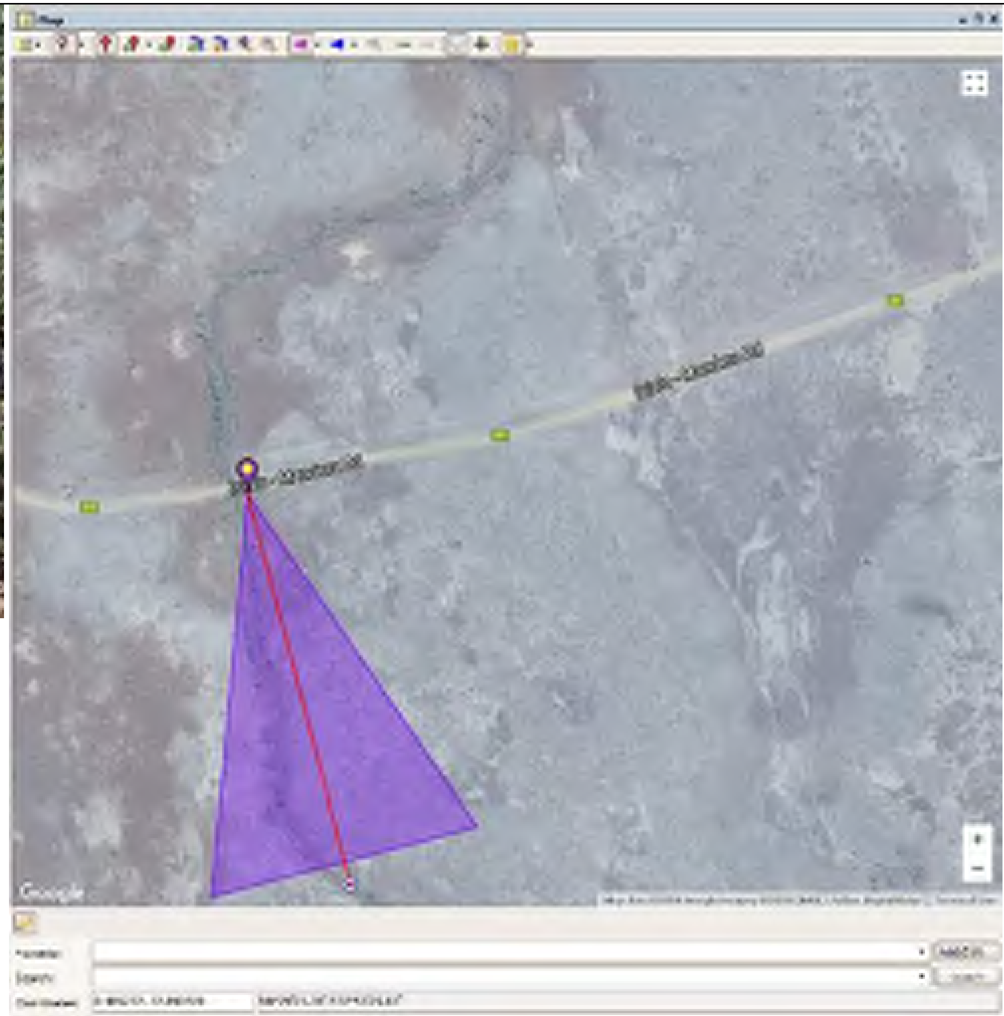
Description: Lhs view if a vented drift.
Coordinates: N0°29'21.68" E37°53'25.40"
Altitude: 1037.3m

Point 8



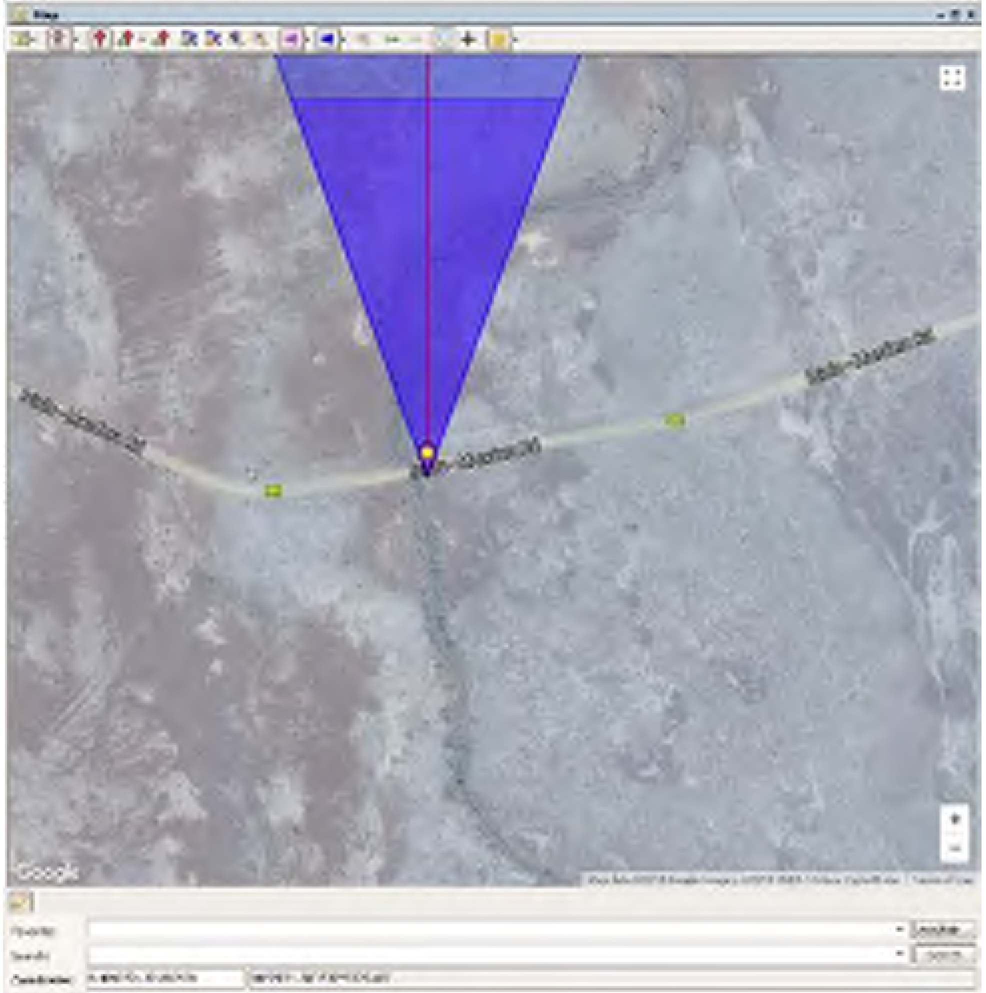
Description: Upstream rhs view if the vented drift.
Coordinates: N0°29'21.38" E37°53'25.83"
Altitude: 1012.0m

Point 8



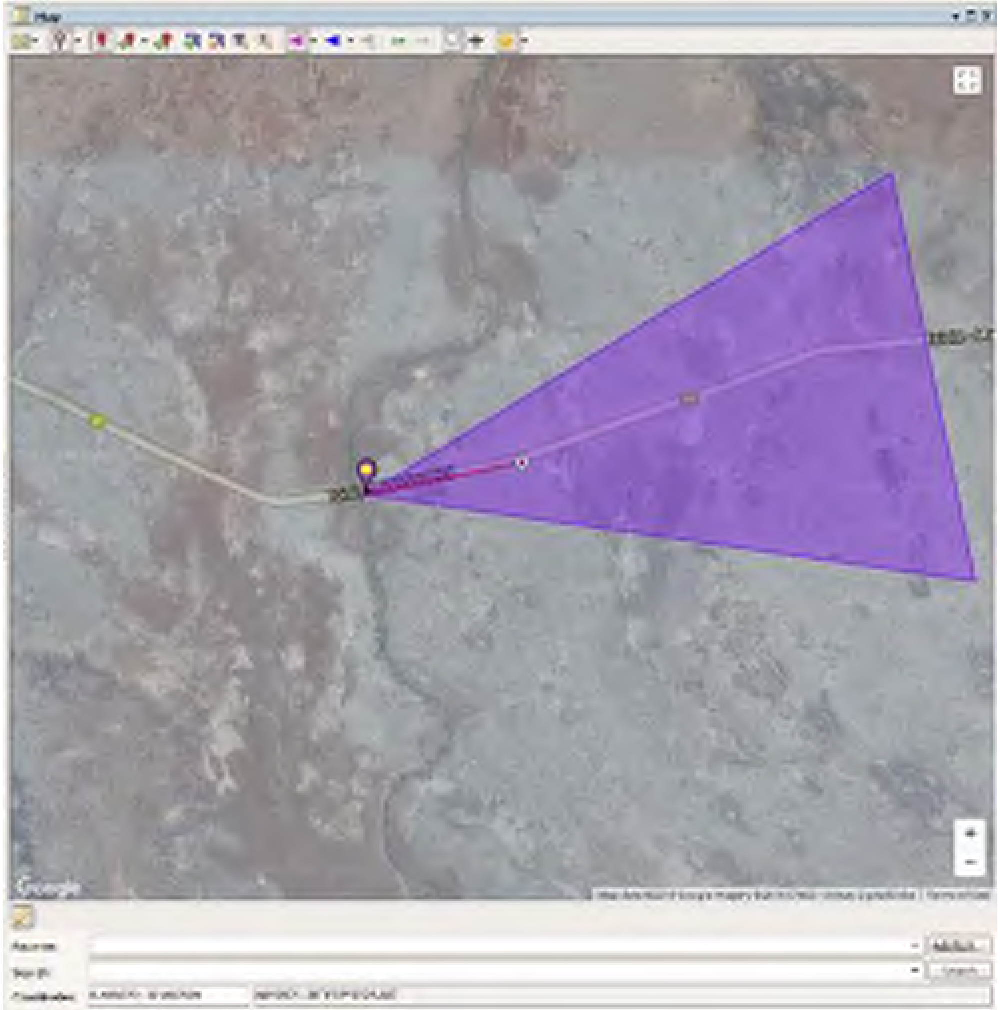
Description: Downstream lhs view of the stream channel at a drift crossing.
Coordinates: N0°29'21.38" E37°53'25.83"
Altitude: 1012.0m

Point 8



Description: Forward view of the approach to the vented drift.
Coordinates: N0°29'21.38" E37°53'25.83"
Altitude: 1012.0m

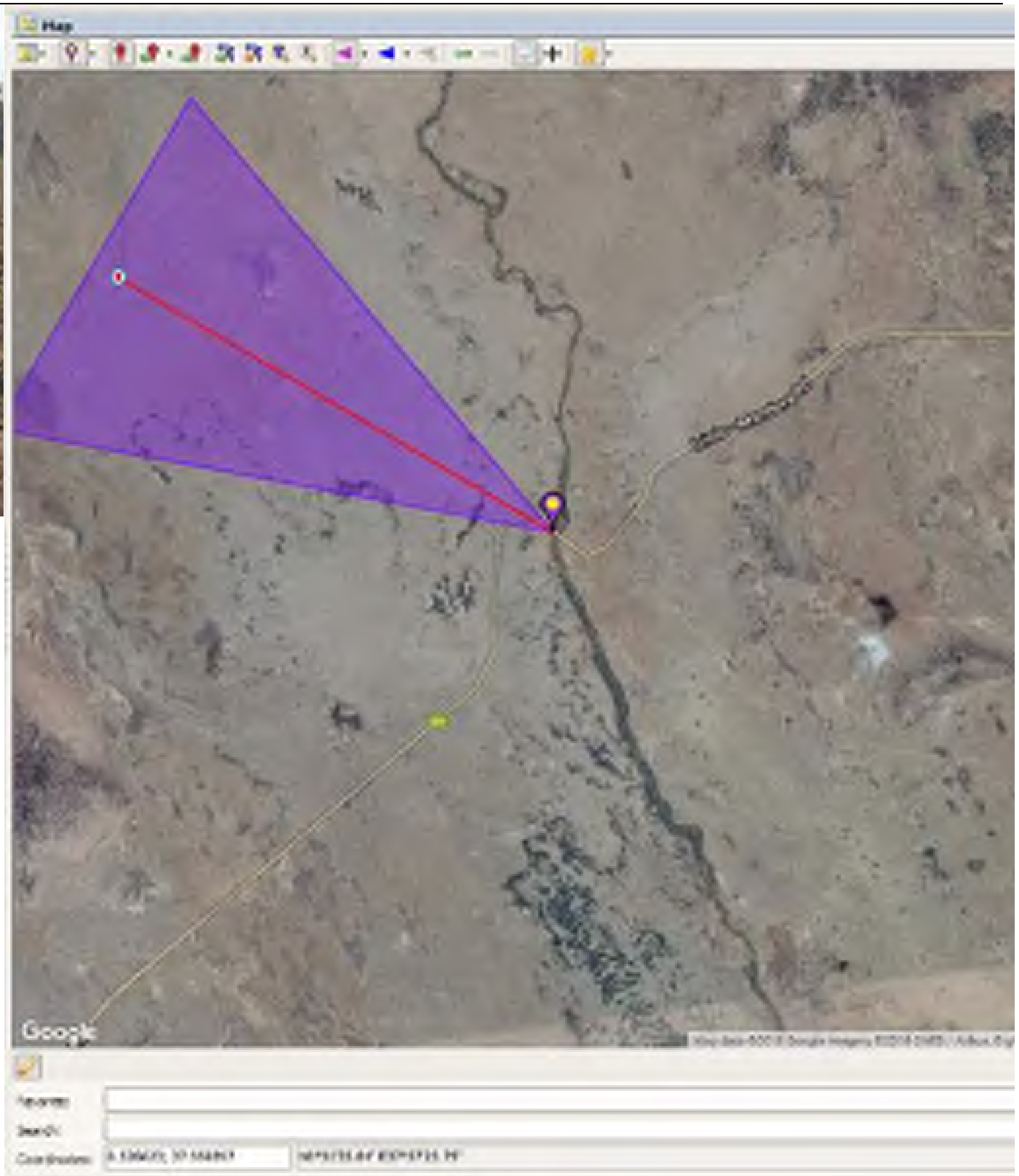
Point 8



The vented drift is scoured at the edges of the outlet side indicating high volumes of water during the wet season.

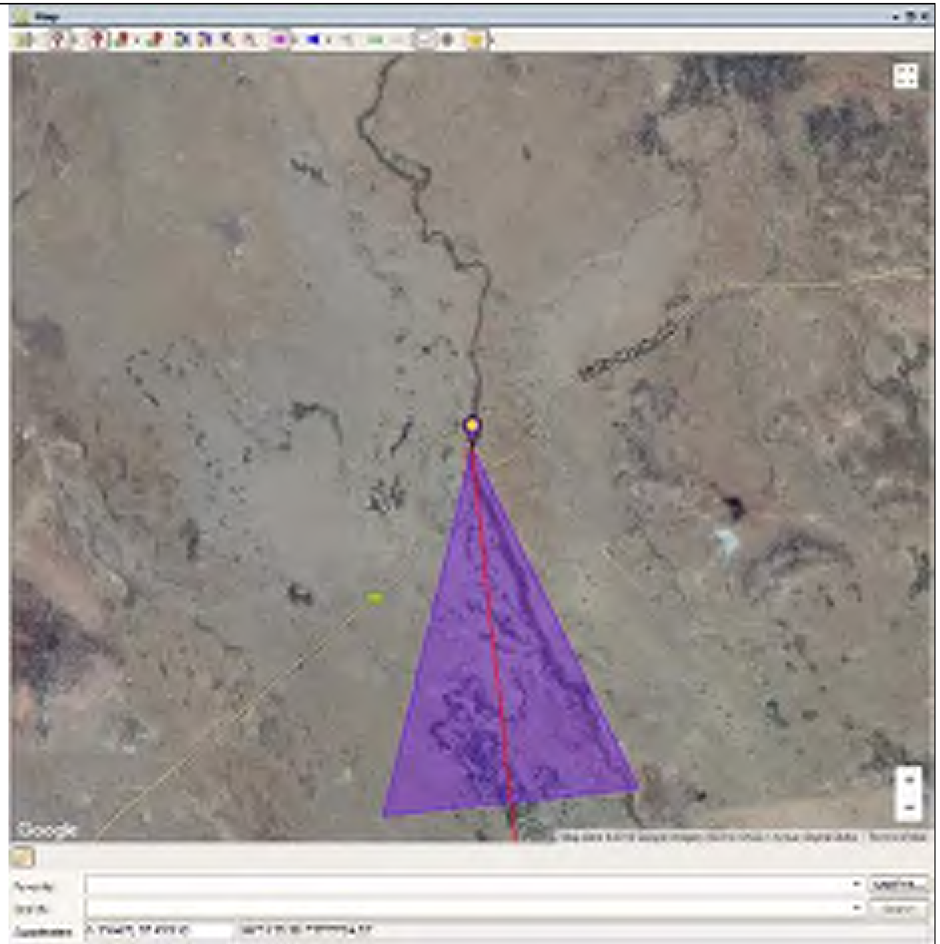
Description: Backward view of the approach to a drift crossing.
Coordinates: N0°29'21.38" E37°53'25.83"
Altitude: 986.0m

Point 9



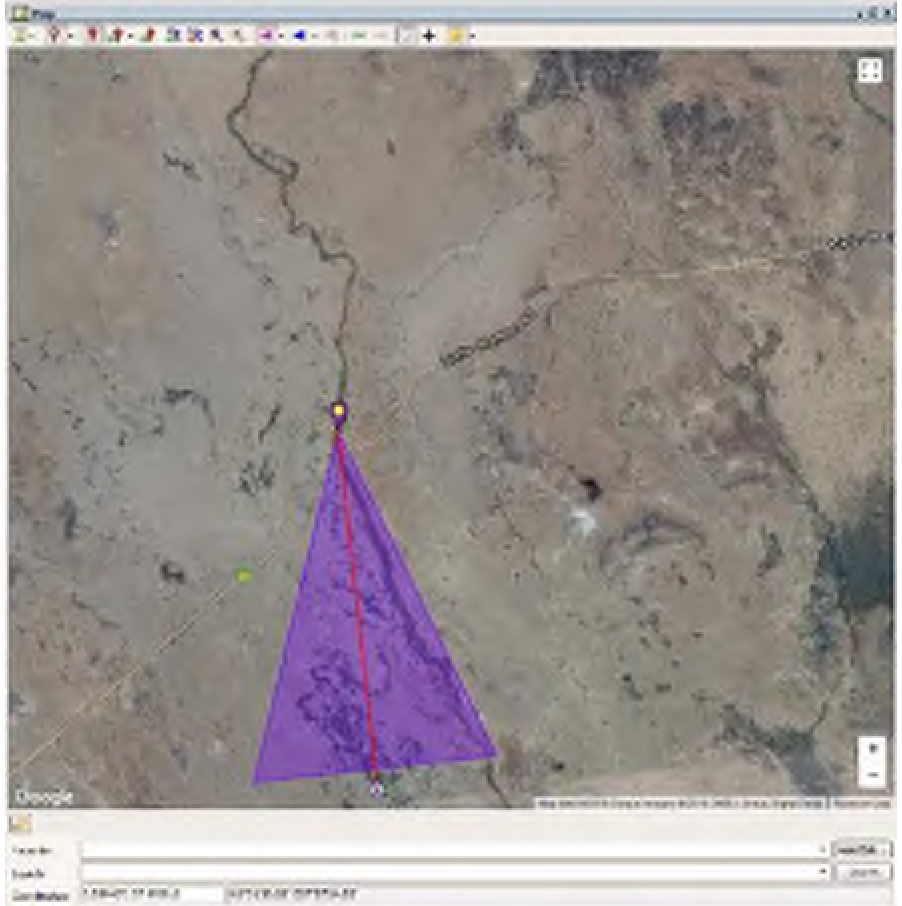
Description: Upstream channel on the lhs of the drift crossing
Coordinates: N0°31'35.28" E37°57'24.52"
Altitude 977.0m

Point 9



Description: Scoured edge at the lhs of the drift crossing. Scour depth is about 1.5m
Coordinates: N0°31'35.28" E37°57'24.52"
Altitude: 977.0m

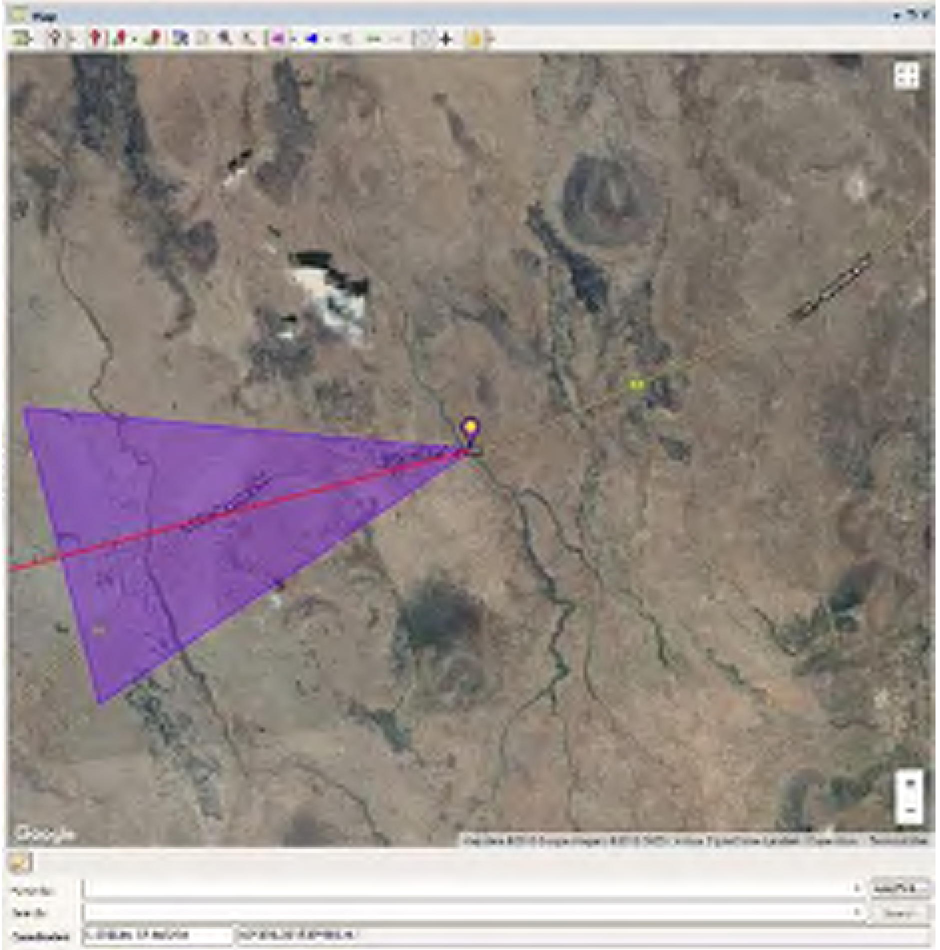
Point 9



There is serious scouring at the outlet of the drift, exposing the rock fill at the bottom of the drift. There is also scouring of about 1m at the downstream exposing rock at the dry riverbed.

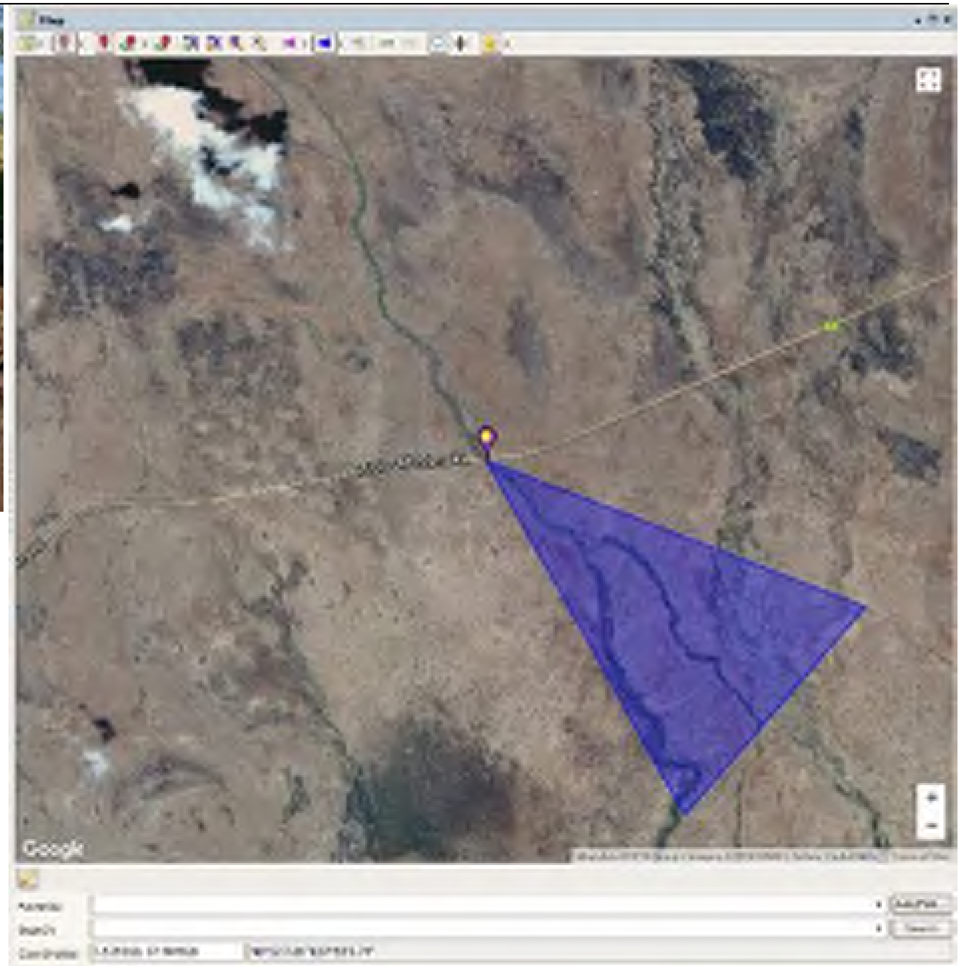
Description: Backward view, approach to a drift
Coordinates: N0°32'8.28" E37°59'6.91"
Altitude: 989.0m

Point 10



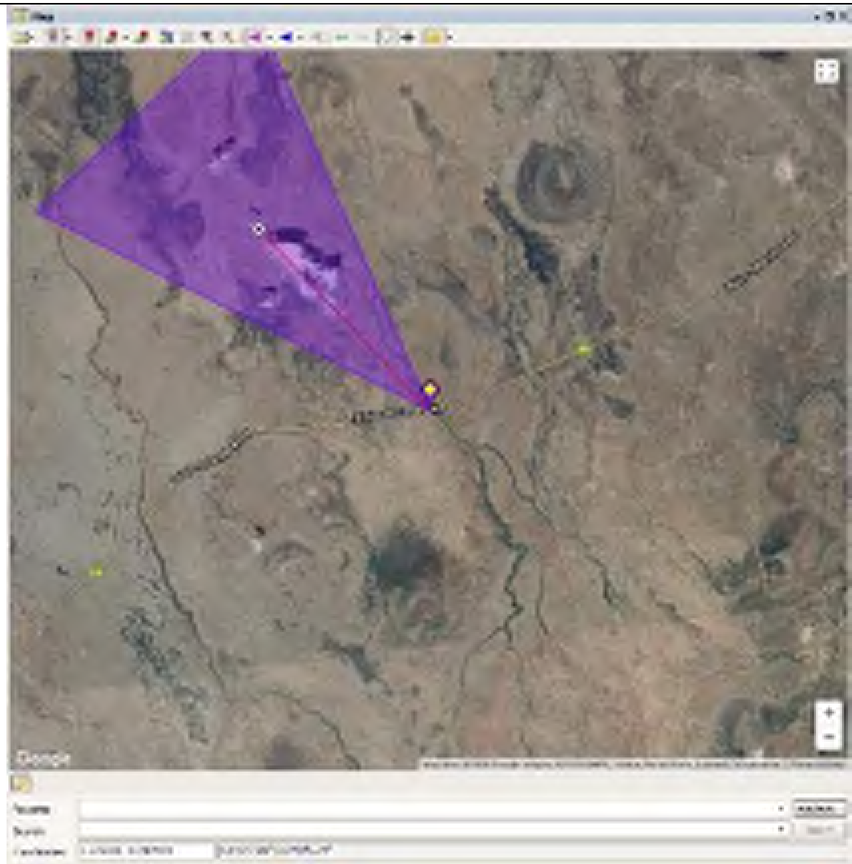
Description: Sandy dry river bed on the upstream rhs of the drift crossing
Coordinates: N0°32'7.86" E37°59'5.74"
Altitude: 974.0m

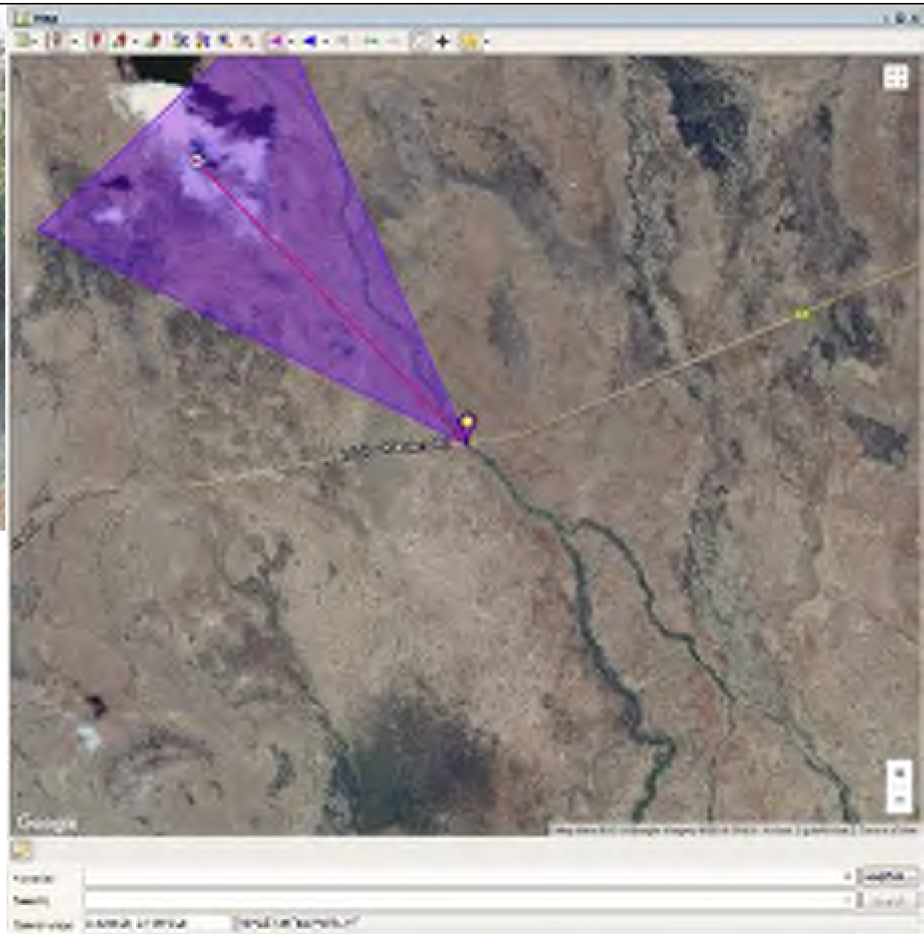
Point 10



Description: Drift location of around 150m long at a channel crossing, with sandy river bed on the upstream.
Coordinates: N0°32'7.86" E37°59'5.74"
Altitude: 974.0m

Point 10



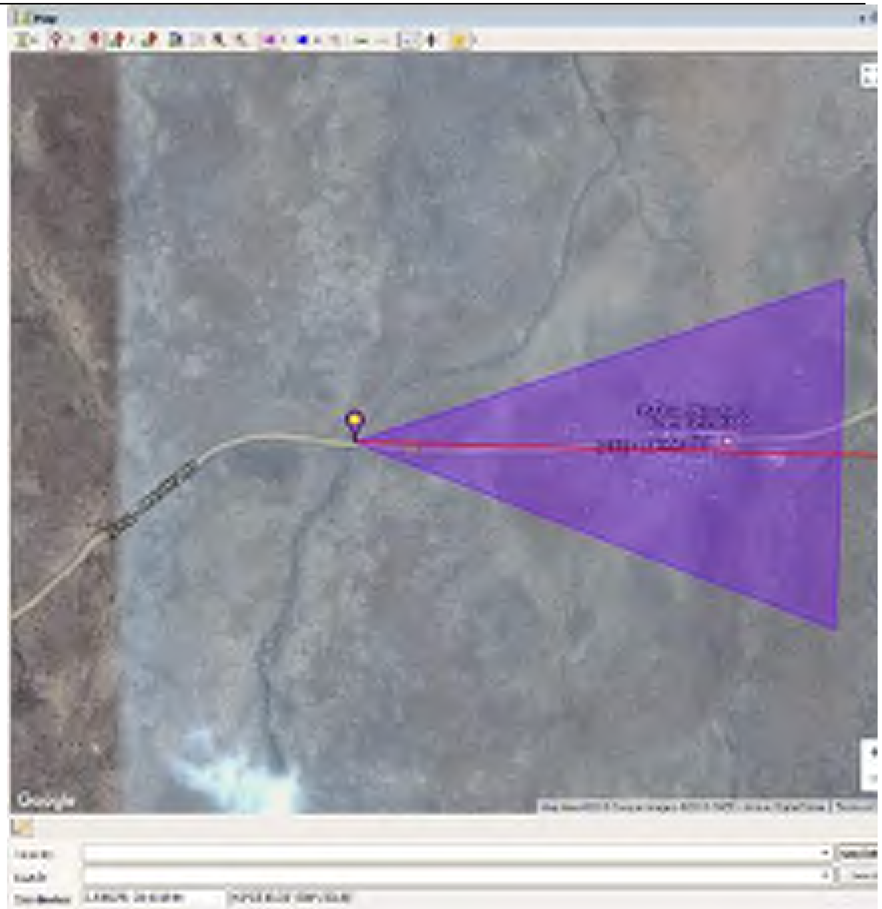


Description: Downstream on the lhs side of a drift location
Coordinates: N0°32'7.86" E37°59'5.74"
Altitude: 974.0a.s.l

Point 10

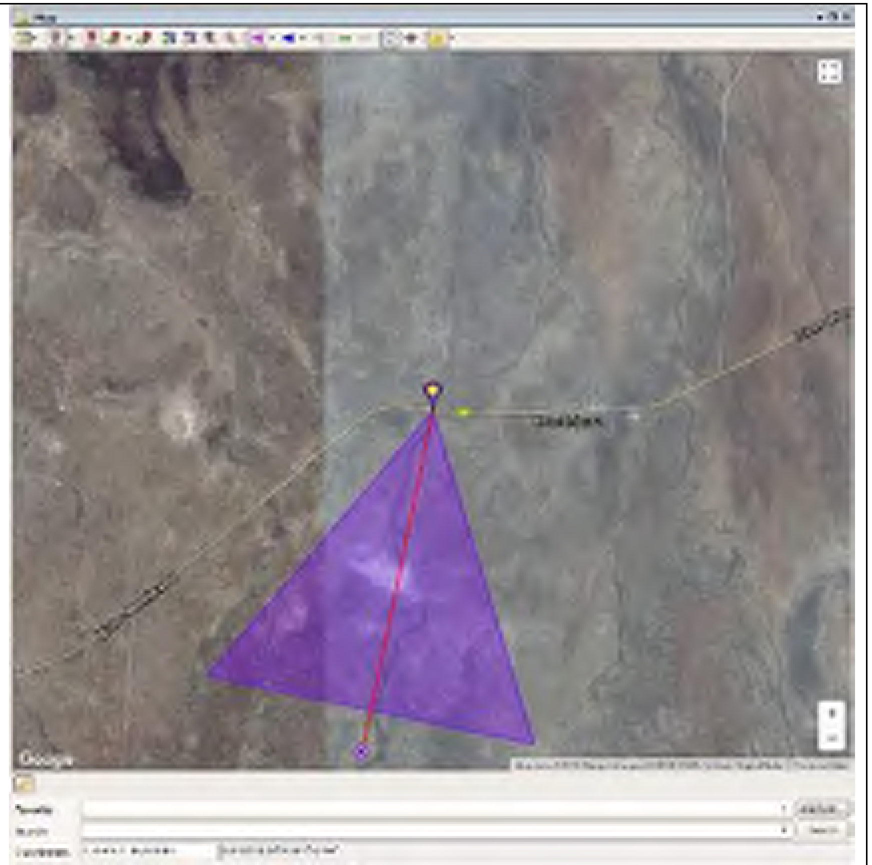
Description: Forward approach to the drift that had previously been washed away and repaired.
Coordinates: N0°33'33.39" E38°1'53.56"
Altitude: 944.0m

Point 10



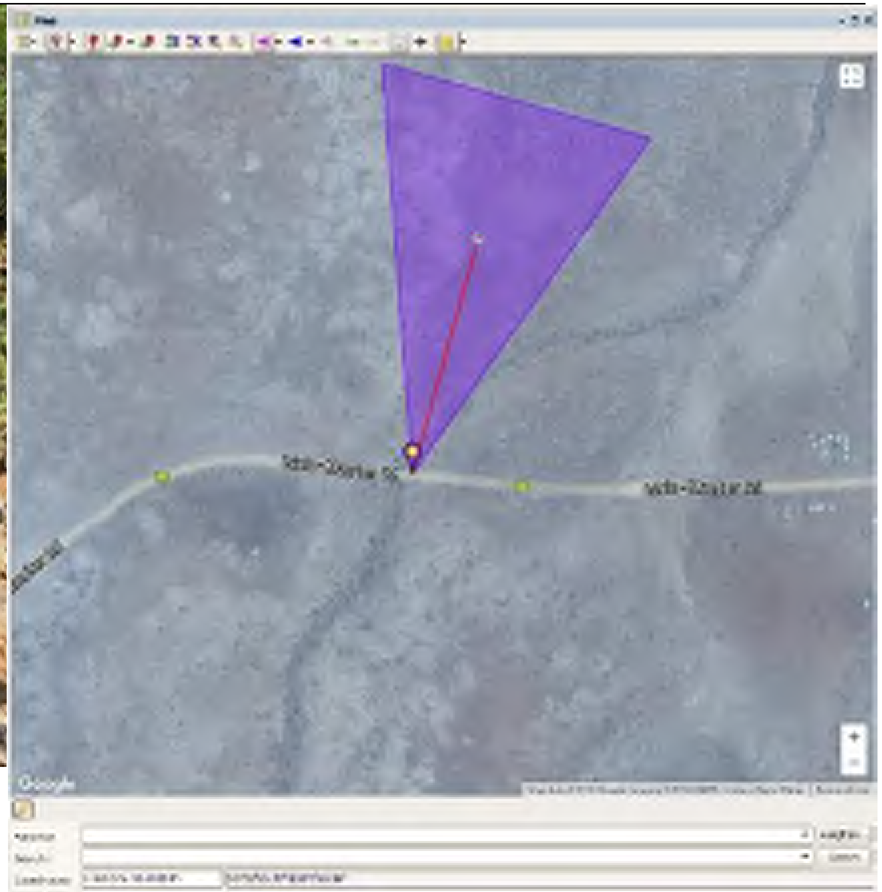
Description: Upstream sandy riverbed on the rhs of the drift crossing.
Coordinates: N0°33'33.00" E38°1'52.98"
Altitude: 963.2m

Point 10



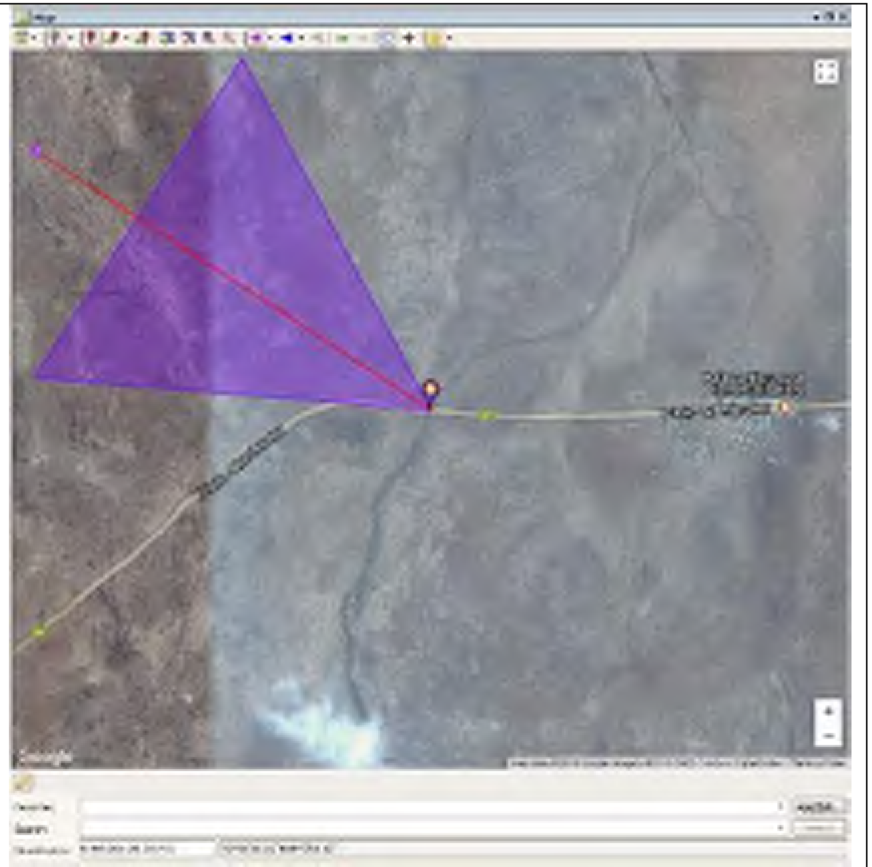
Description: Heavily scoured downstream channel on the lhs of a drift. The scouring is about 4m deep.
Coordinates: N0°33'33.39" E38°1'53.56"
Altitude: 944.0m

Point 10



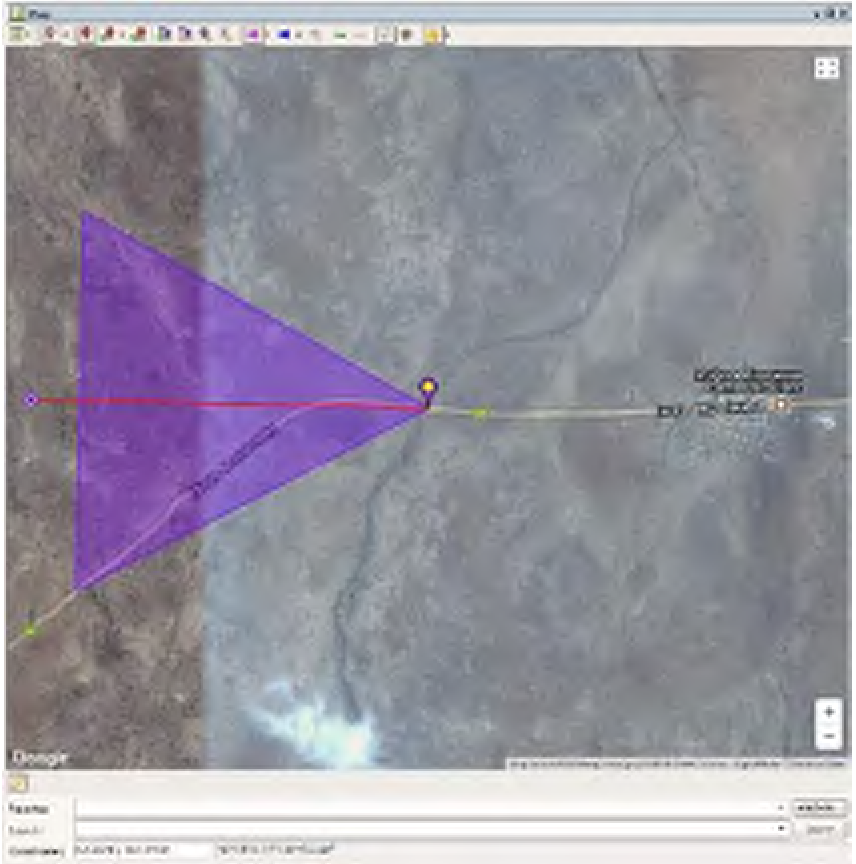
Description: Pieces of previously washed out drift
Coordinates: N0°33'33.31" E38°1'53.30"
Altitude: 966.0m

Point 10



Description: Backward view of the approach to the drift crossing.
Coordinates: N0°33'33.27" E38°1'53.69"
Altitude: 964.6m

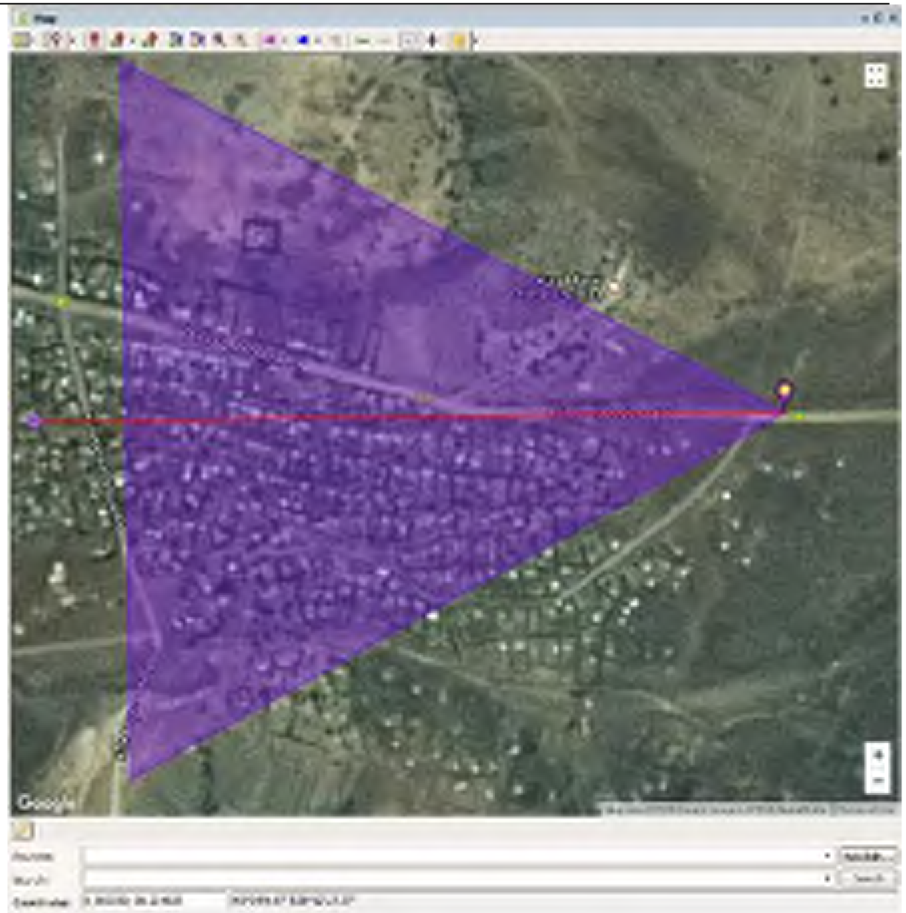
Point 10

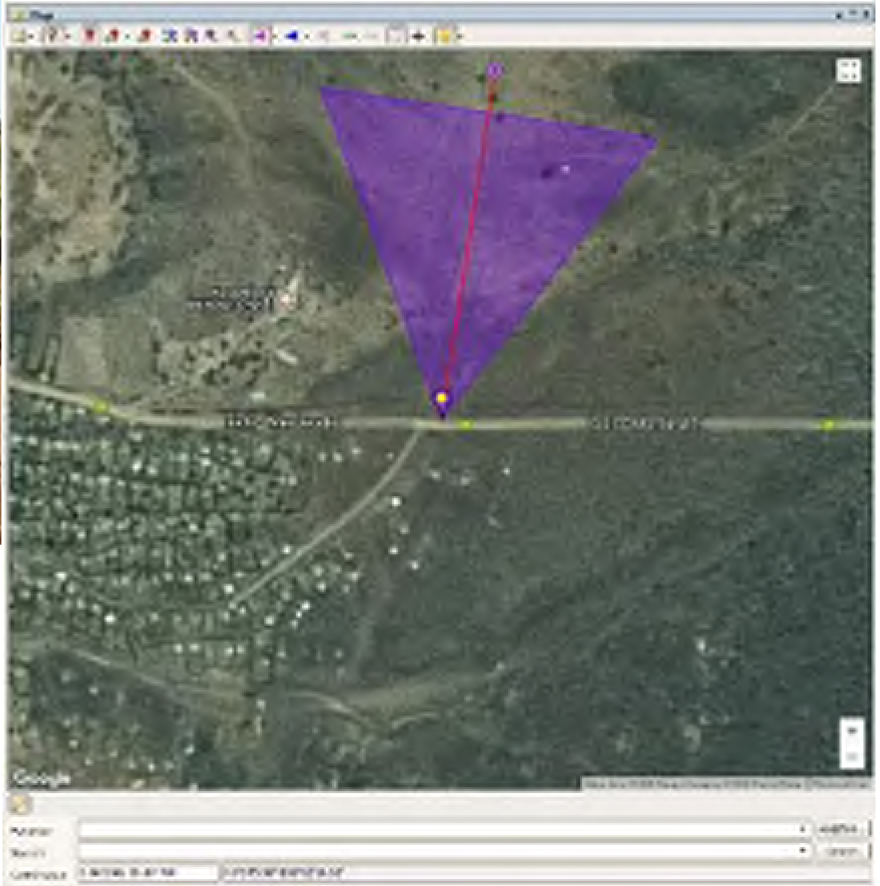


According to the KeNHA inspector, the 150m drift has a history of being washed regularly, indicating presence of a lot of discharge with high speed. This was evident from the large pieces of concrete seen on the downstream. The downstream section is also seriously scoured to depths of around 4m, indicating need for protection by use of gabions.

Description: Backward view of the approach to a drift crossing after Kula Mawe village, and junction to Maua town in Meru
Coordinates: N0°33'33.27" E38°1'53.69"
Altitude: 711.4m

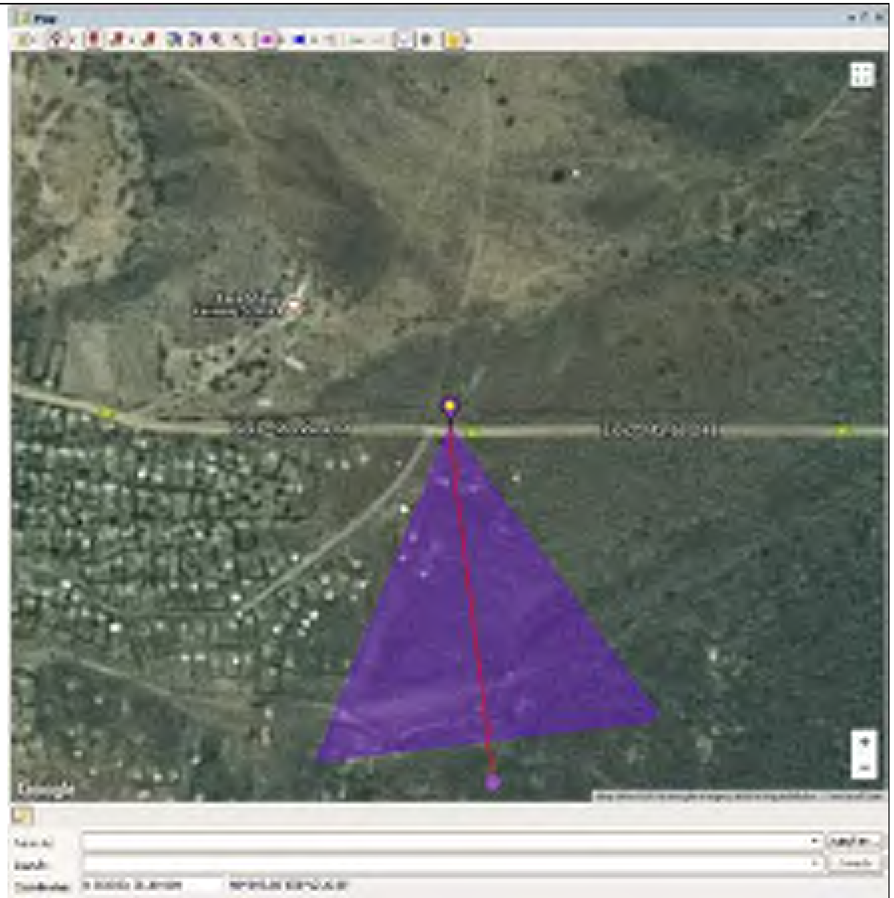
Point 11





Description: Downstream view at the drift crossing on the lhs.
Coordinates: N0°34'9.68" E38°12'16.92"
Altitude: 711.4m

Point 11



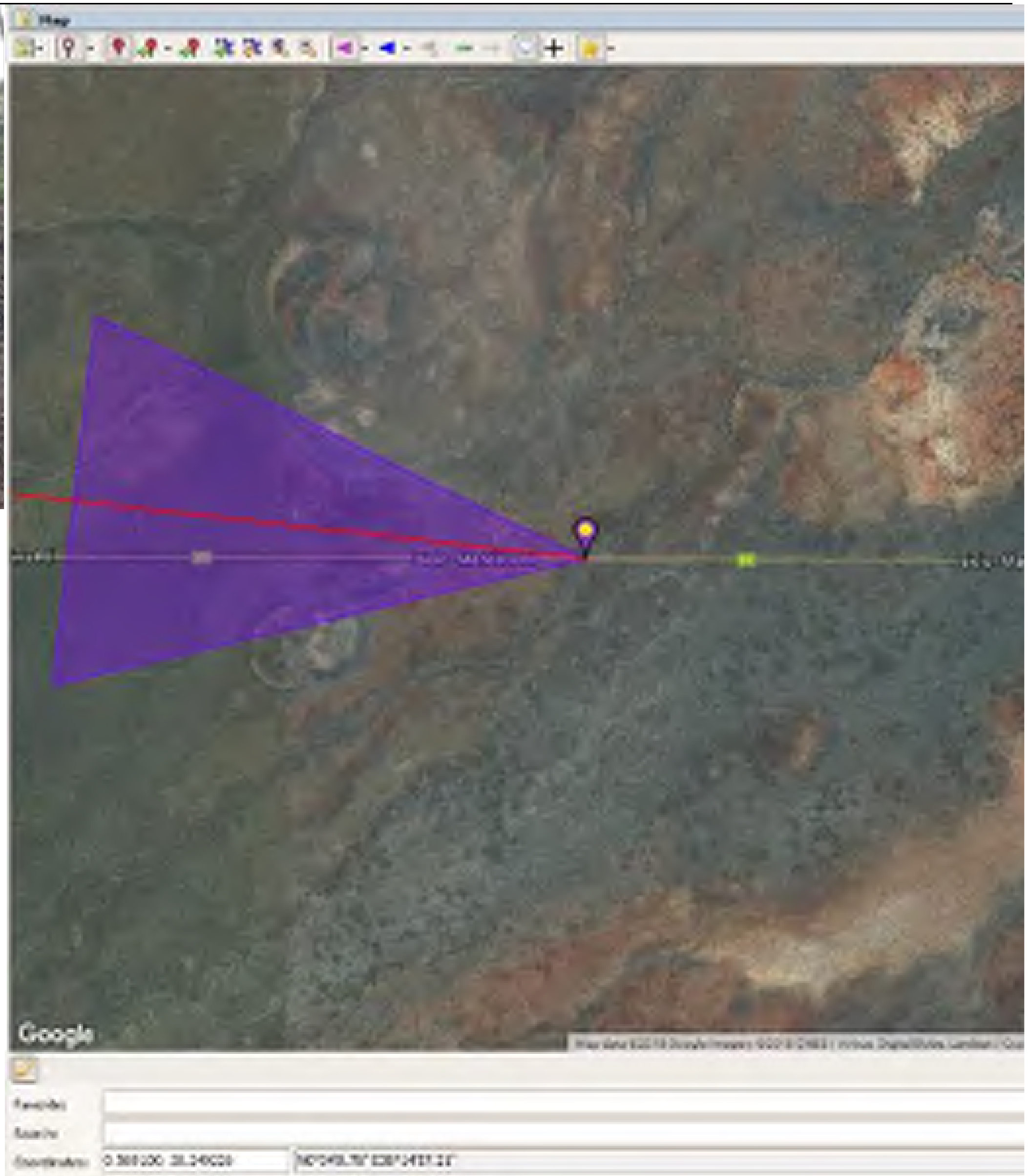
Description: Side view at the drift crossing on the rhs.
Coordinates: N0°34'9.66" E38°12'16.88"
Altitude: 711.4m

Point 11

Drift location after Kula Mawe village.

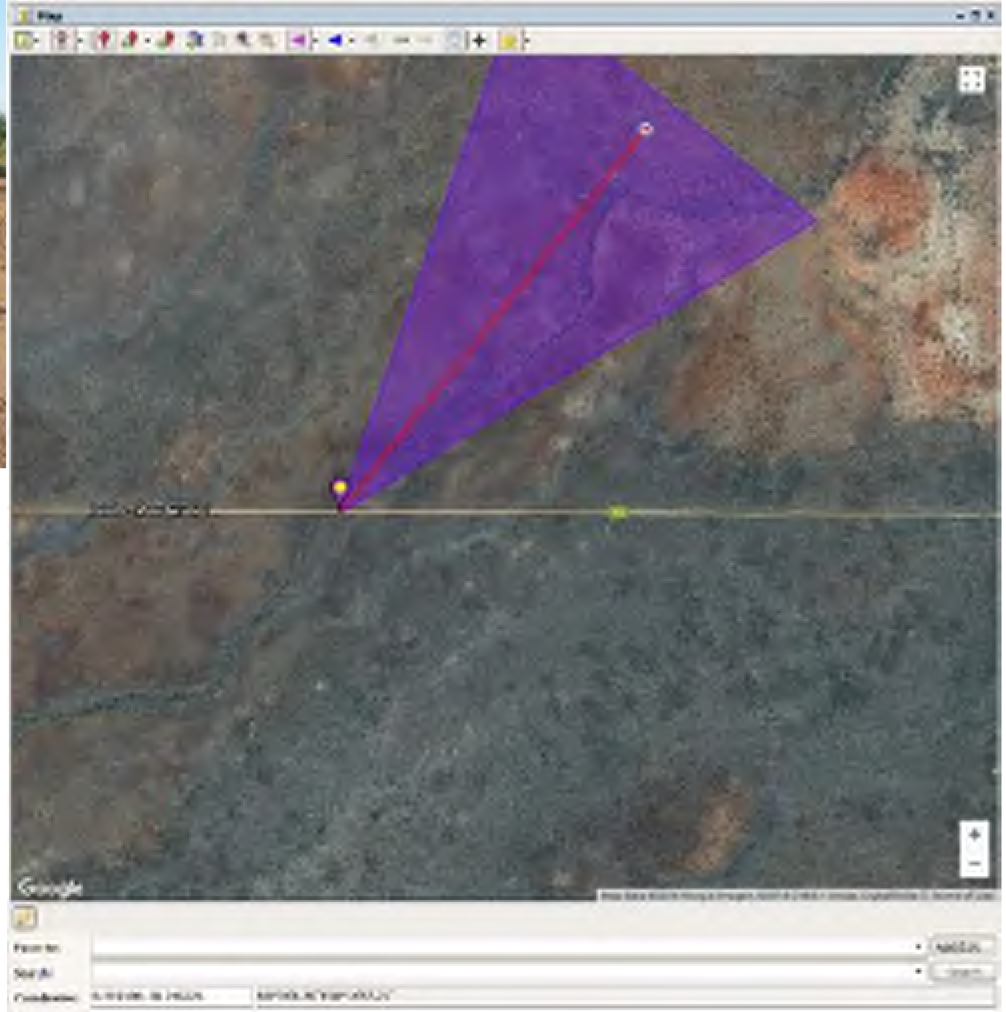
Description: Backward view on the approach to a deteriorated drift crossing.
Coordinates: N0°34'8.76" E38°14'57.21"
Altitude: 669.0m

Point 12



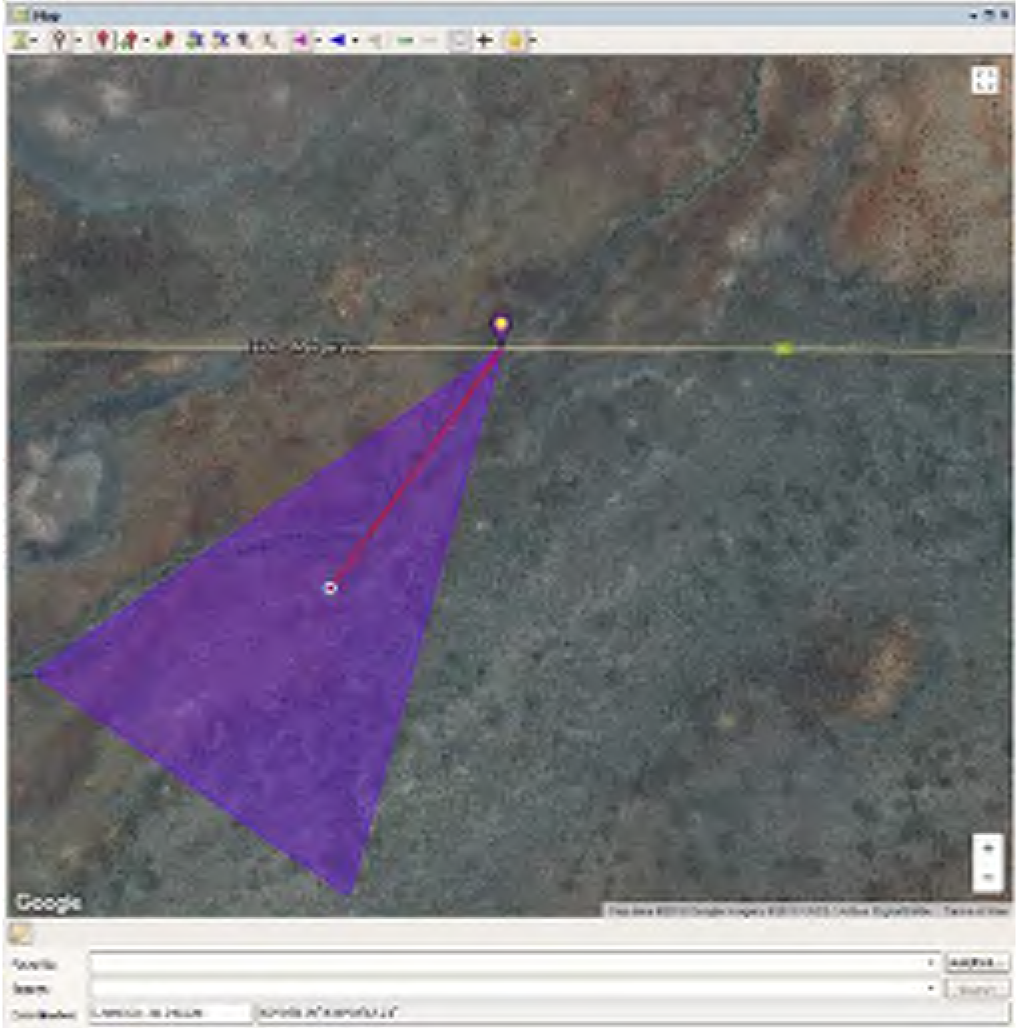
Description: Downstream view on the lhs of the drift.
Coordinates: N0°34'8.76" E38°14'57.21"
Altitude: 669.0m

Point 12



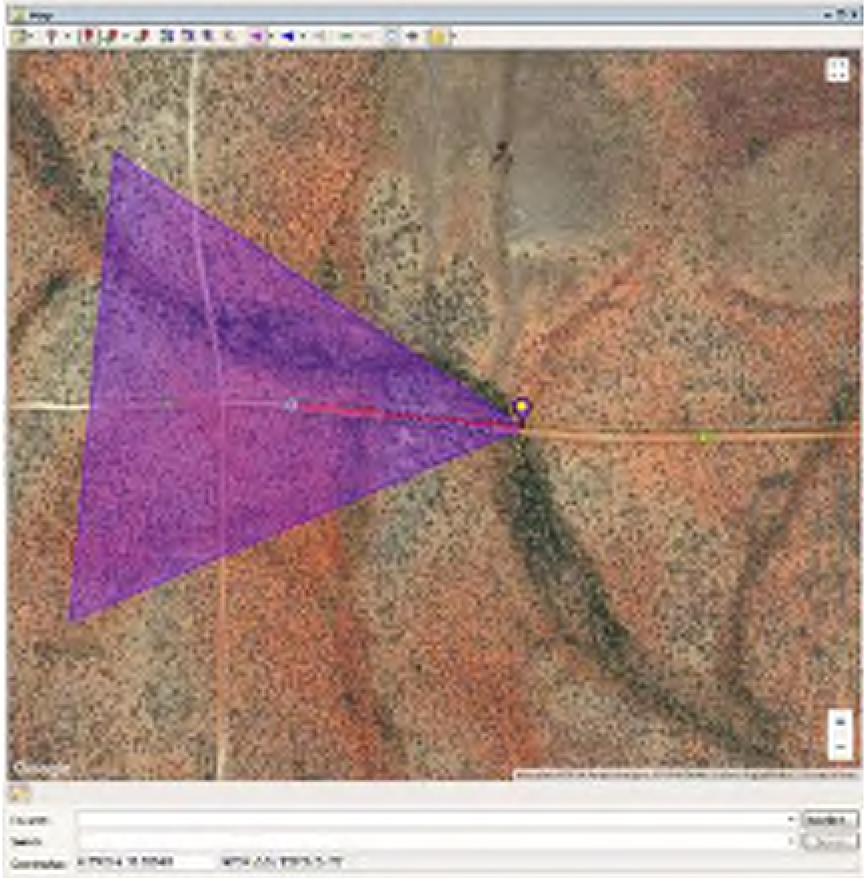
Description: Upstream view on the rhs of the drift.
Coordinates: N0°34'8.76" E38°14'57.21"
Altitude: 669.0m

Point 12



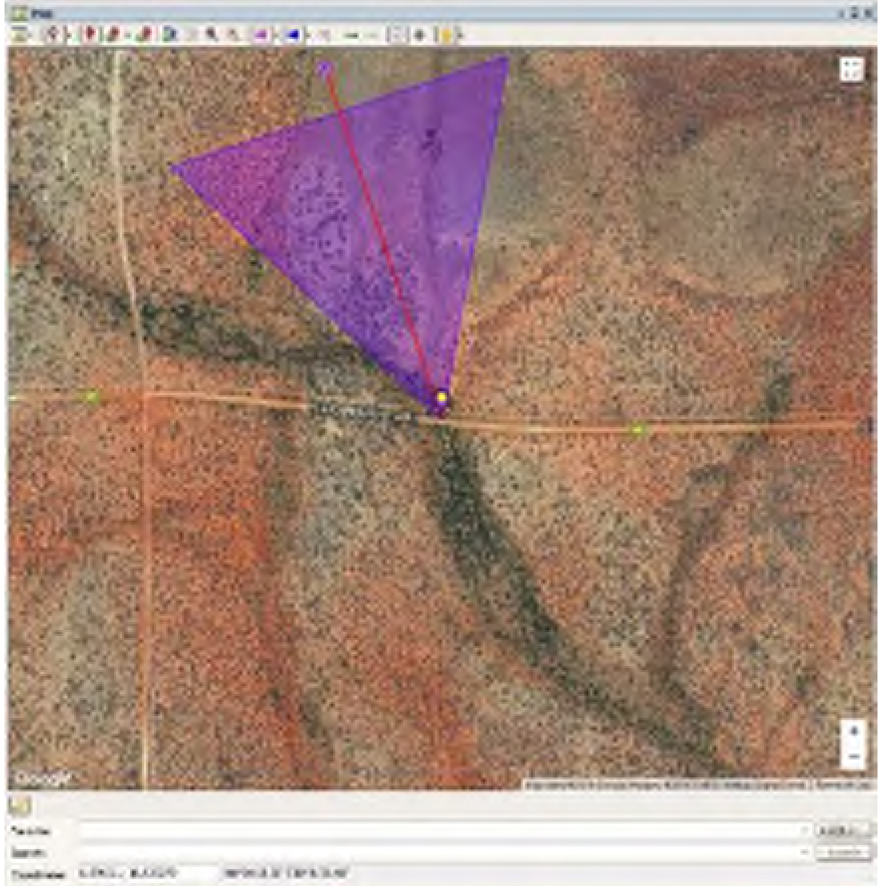
Description: Backward view of a drift location that has been covered by sand.
Coordinates: N0°34'13.31" E38°31'31.76"
Altitude: 535.1m

Point 13



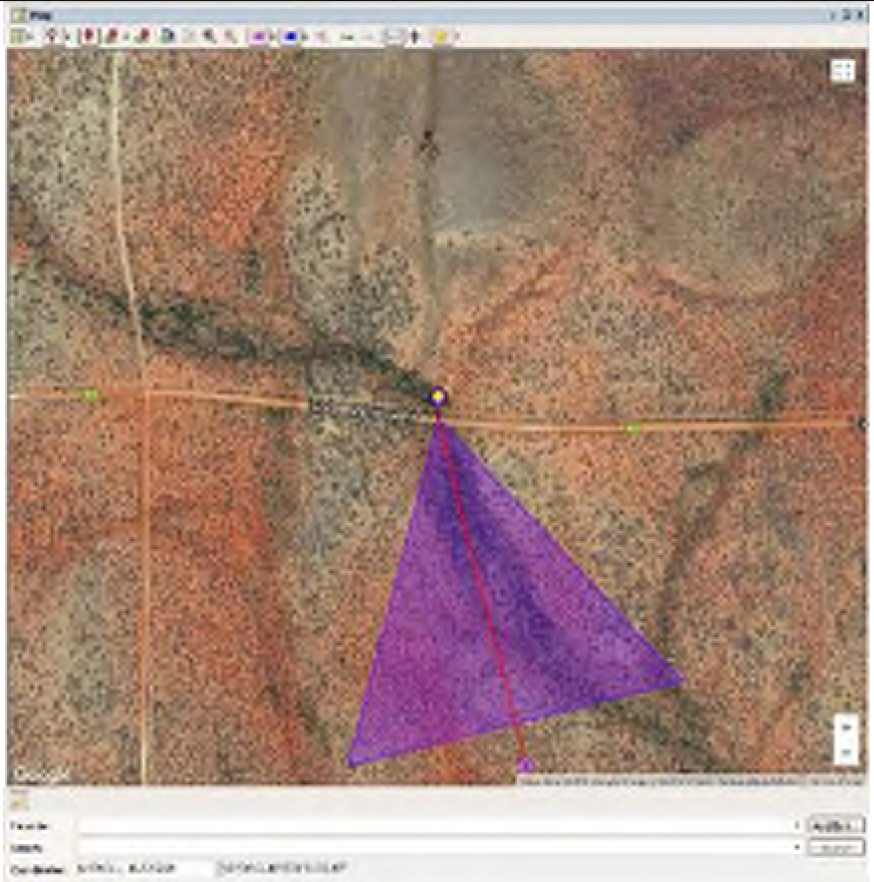
Description: Downstream view on the lhs of a drift, with riverbed filled with sand, and with indications of scouring to a depth of about 1m.
Coordinates: N0°34'13.30" E38°31'30.98"
Altitude: 527.4m

Point 13



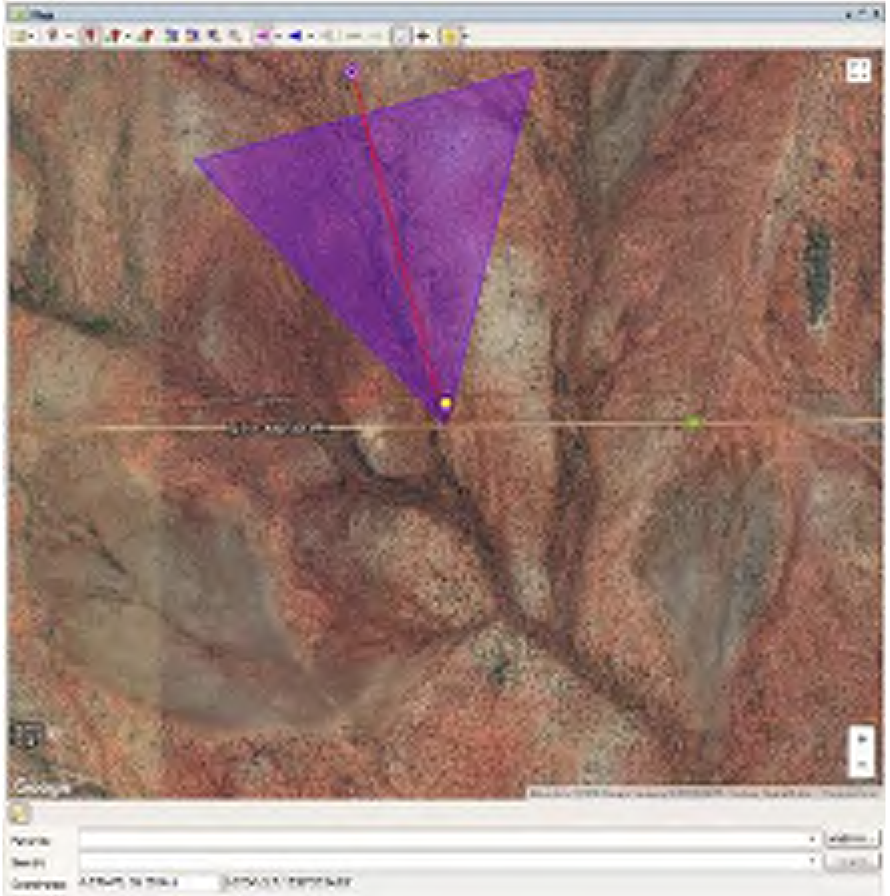
Description: Upstream view on the rhs of a drift, with riverbed filled with sand.
Coordinates: N0°34'13.30" E38°31'30.97"
Altitude: 527.6m

Point 13



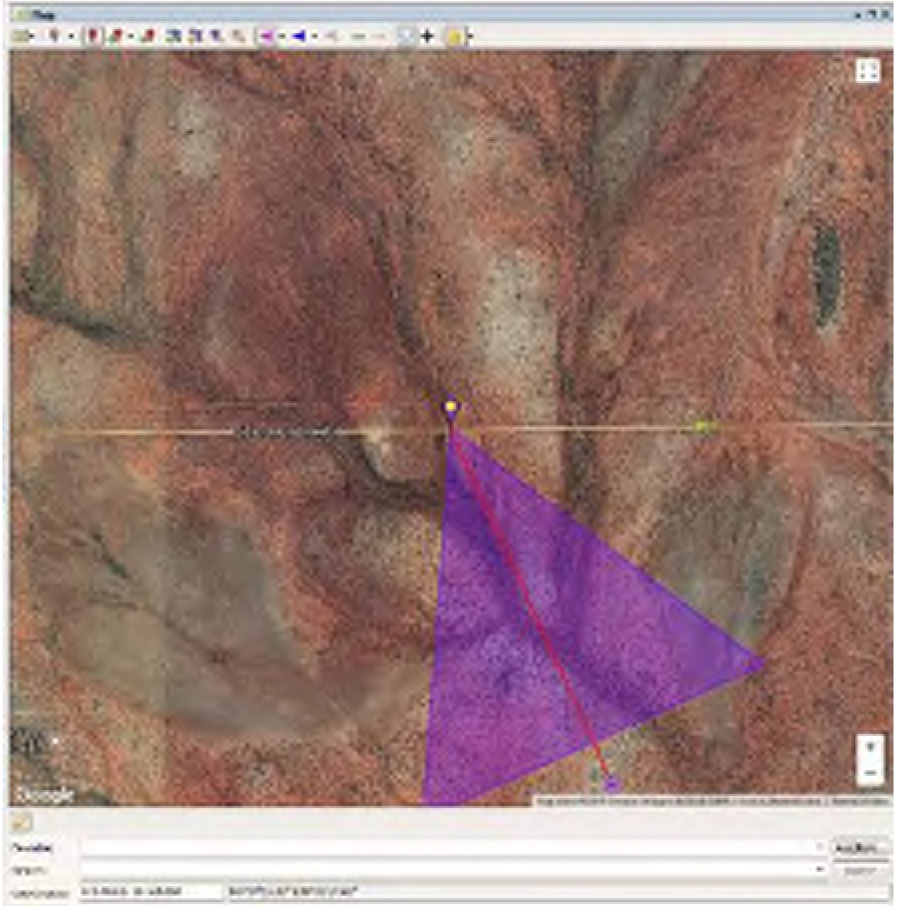
Description: Downstream view of a sandy riverbed on the lhs of a drift.
Coordinates: N0°34'13.71" E38°33'24.88"
Altitude: 505.6m

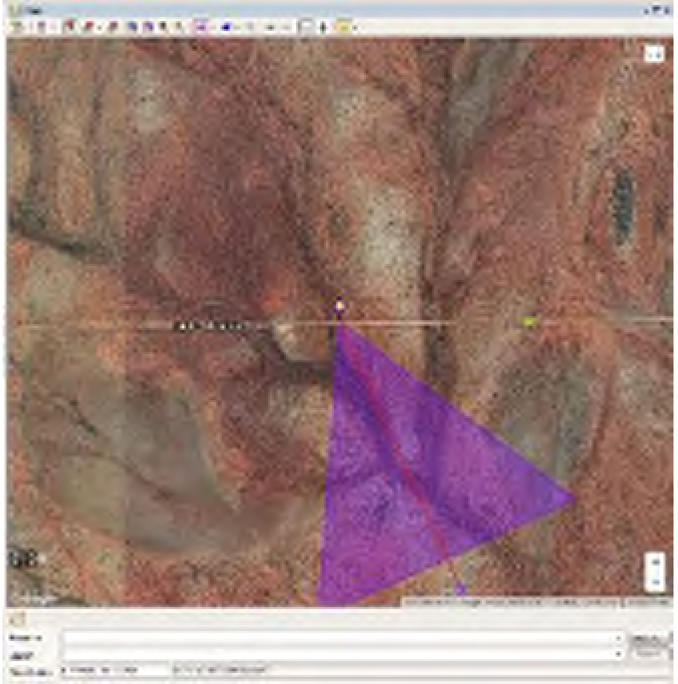
Point 14



Description: Upstream view of a sandy riverbed on the rhs of a drift.
Coordinates: N0°34'13.83" E38°33'24.69"
Altitude: 509.9m

Point 14



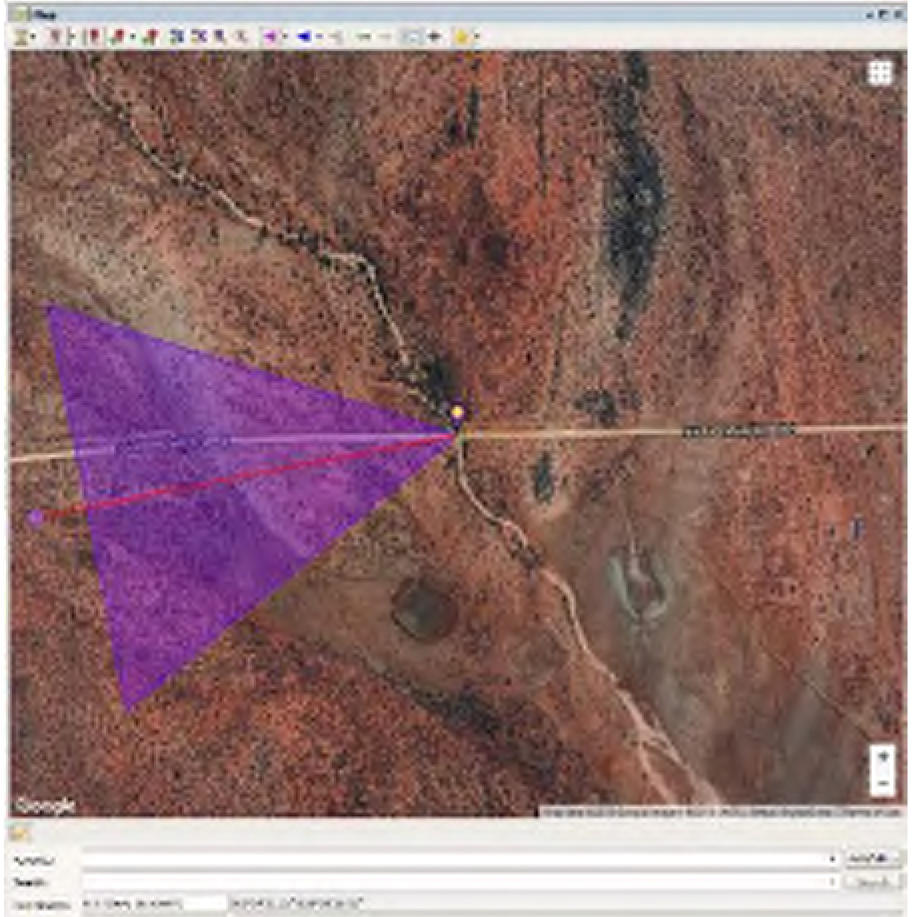


Description: Panoramic view of the Upstream on the rhs of a drift, with riverbed filled with sand.
Coordinates: N0°34'13.83" E38°33'24.69"
Altitude: 509.1m

Point 14

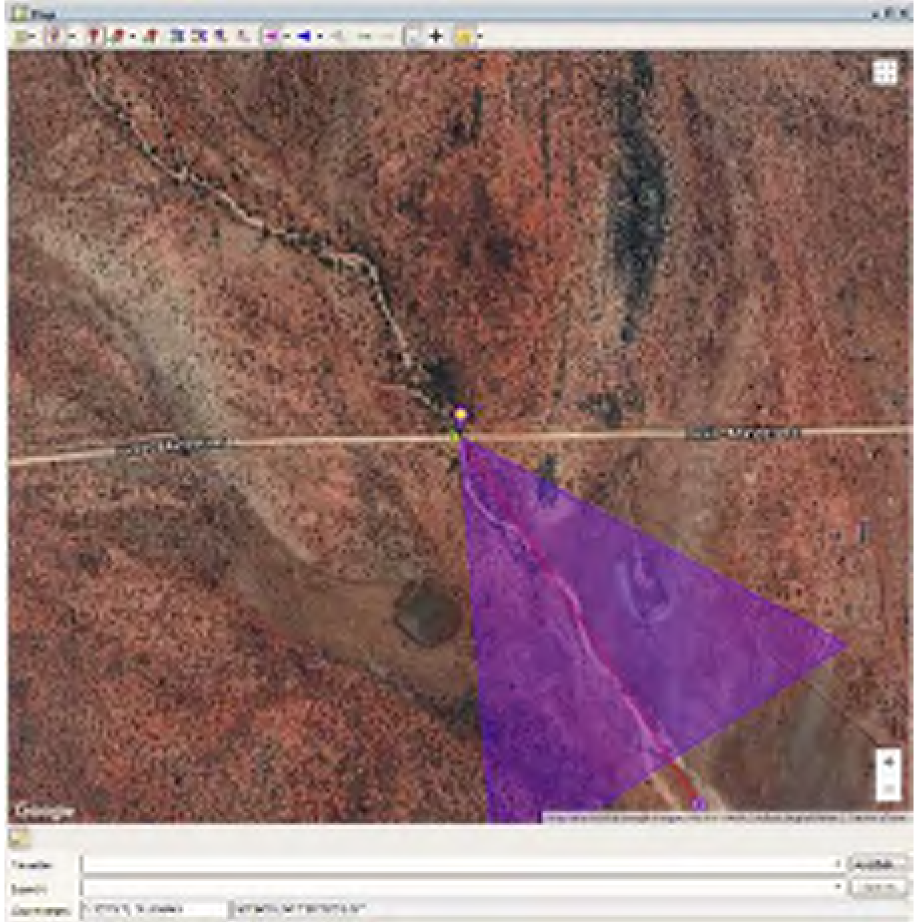
Description: Backward view of a drift, about 200m long.
Coordinates: N0°34'21.23" E38°36'25.10"
Altitude: 485.1m

Point 15



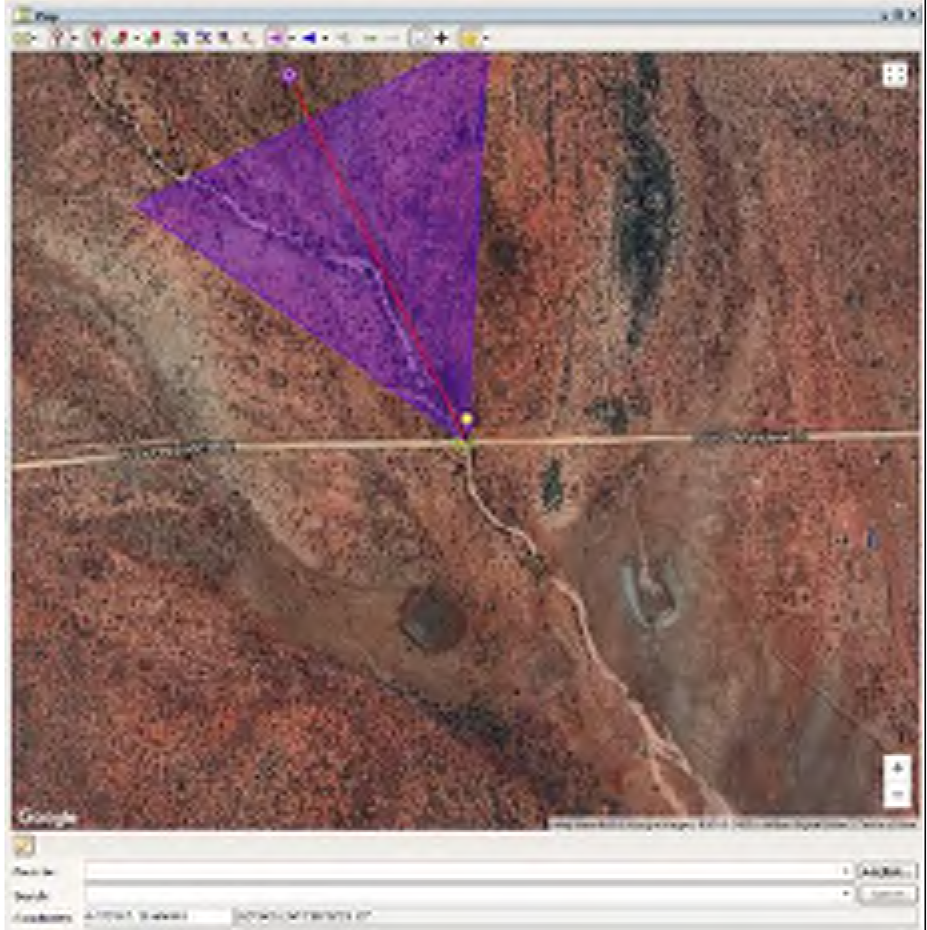
Description: Downstream view of a sandy river bed on the rhs of a drift with scouring of about 1m.
Coordinates: N0°34'21.24" E38°36'25.06"
Altitude: 487.5m

Point 15



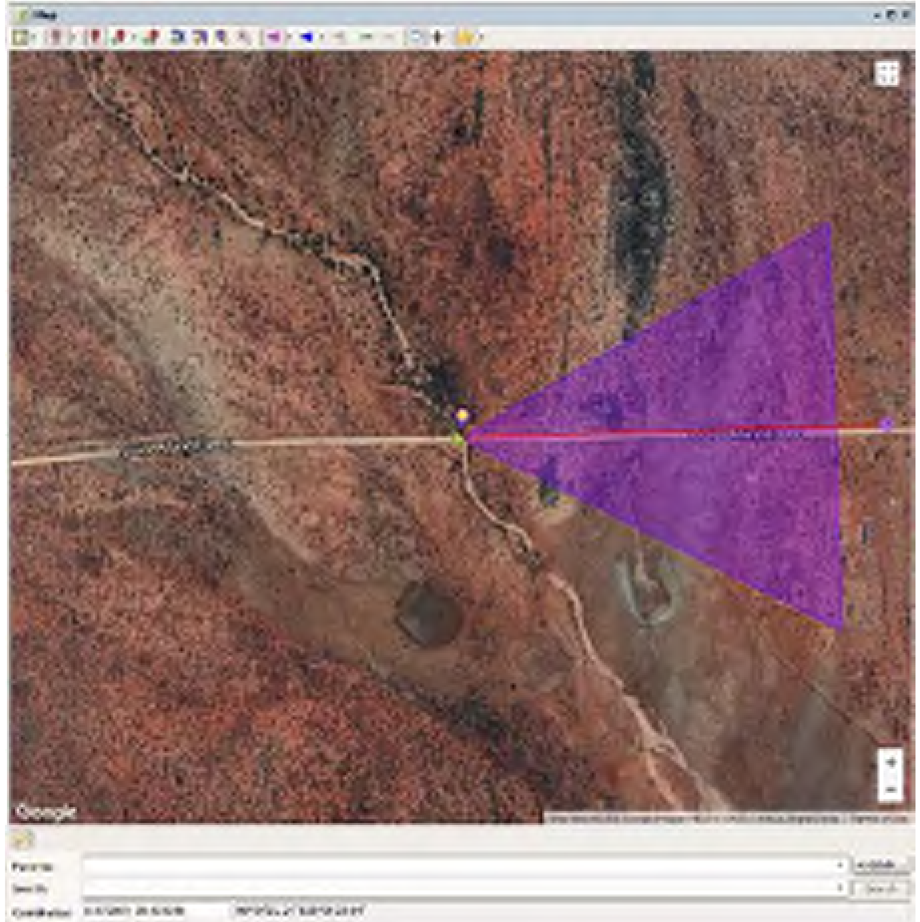
Description: Upstream view of a sandy river bed on the lhs of a drift.
Coordinates: N0°34'21.24" E38°36'25.15"
Altitude: 485.2m

Point 15



Description: Forward view at a drift crossing.
Coordinates: N0°34'21.24" E38°36'25.04"
Altitude: 488.5m

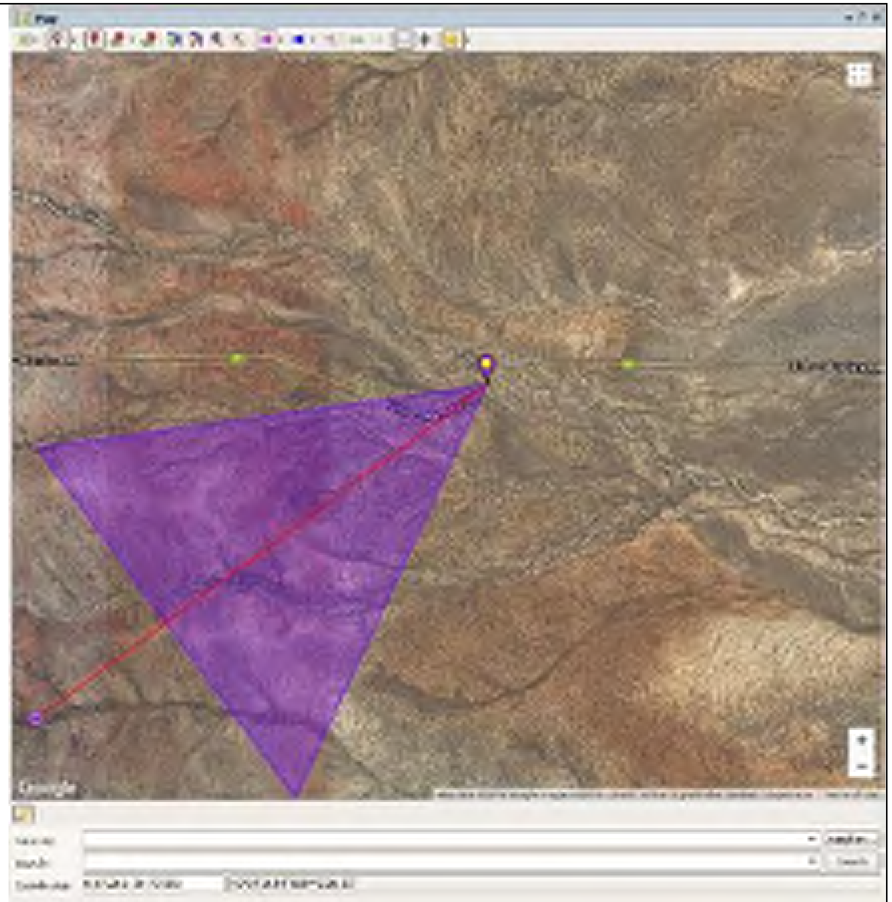
Point 15



At this drift location, the water approaches the drift from several directions and the large volume of water has caused scouring on the downstream. There is also a large sand deposit on the riverbed both upstream and downstream.

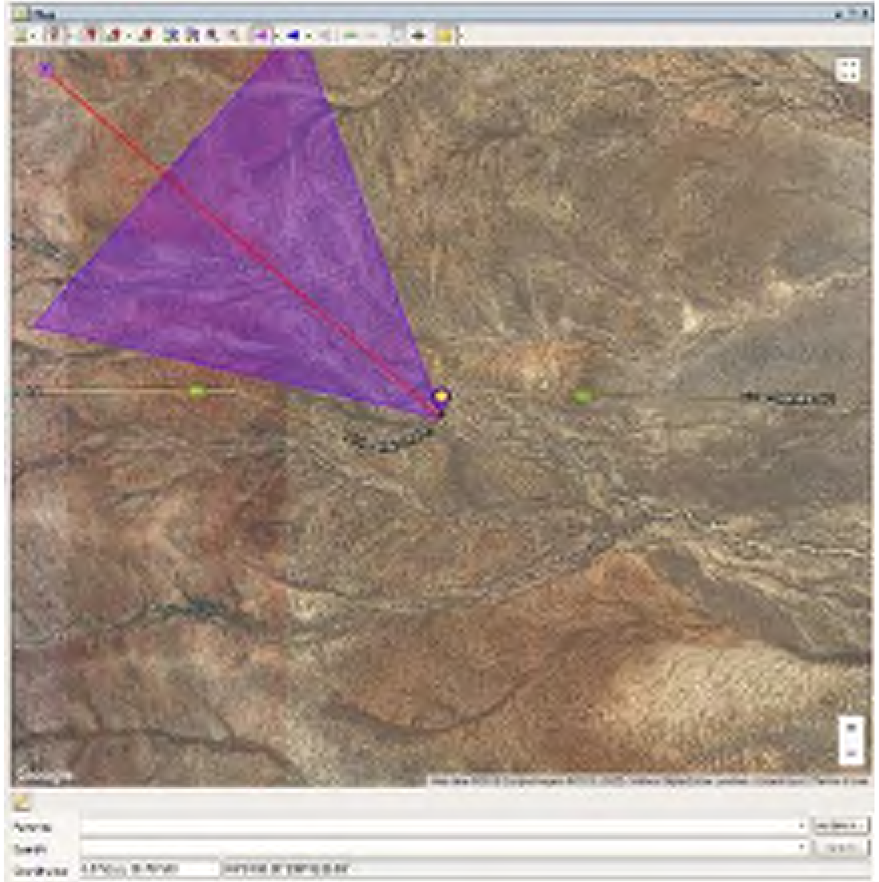
Description: Backward view of a drift of about 200m, with wide river beds.
Coordinates: N0°34'16.54" E38°42'26.11"
Altitude: 431.5m

Point 16



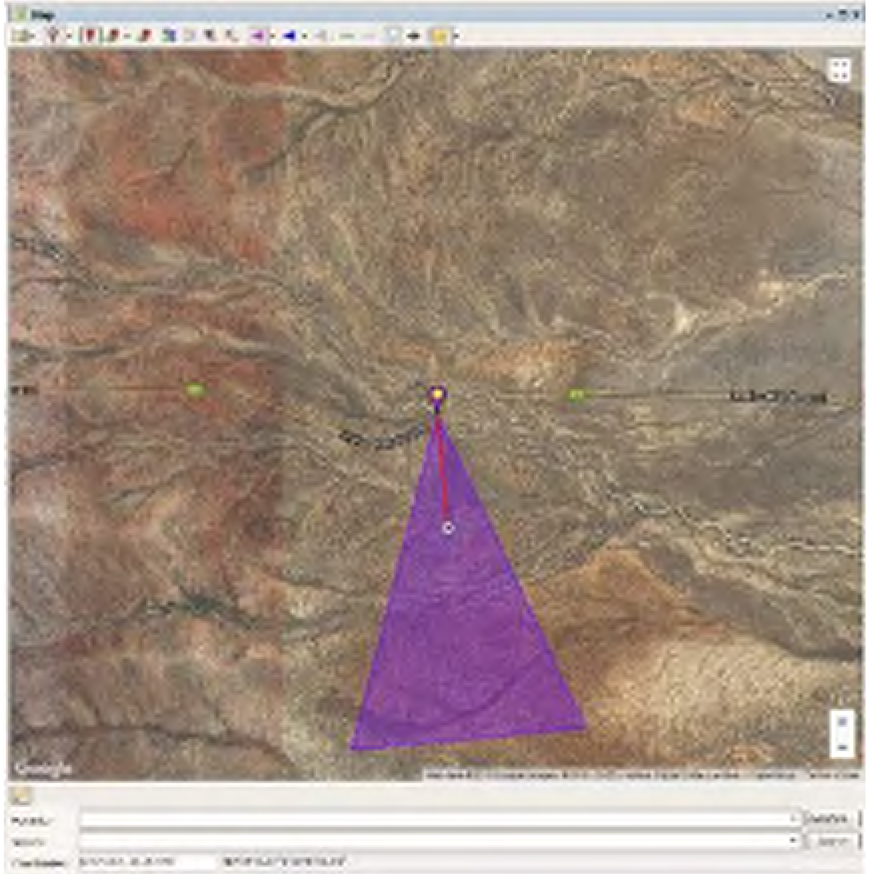
Description: About 150m wide downstream river bed filled with sand and branches of trees carried by water on the lhs.
Coordinates: N0°34'16.36" E38°42'25.86"
Altitude: 430.2m

Point 16



Description: About 150m wide upstream river bed filled with sand on the rhs.
Coordinates: N0°34'16.61" E38°42'26.09"
Altitude: 414.0m

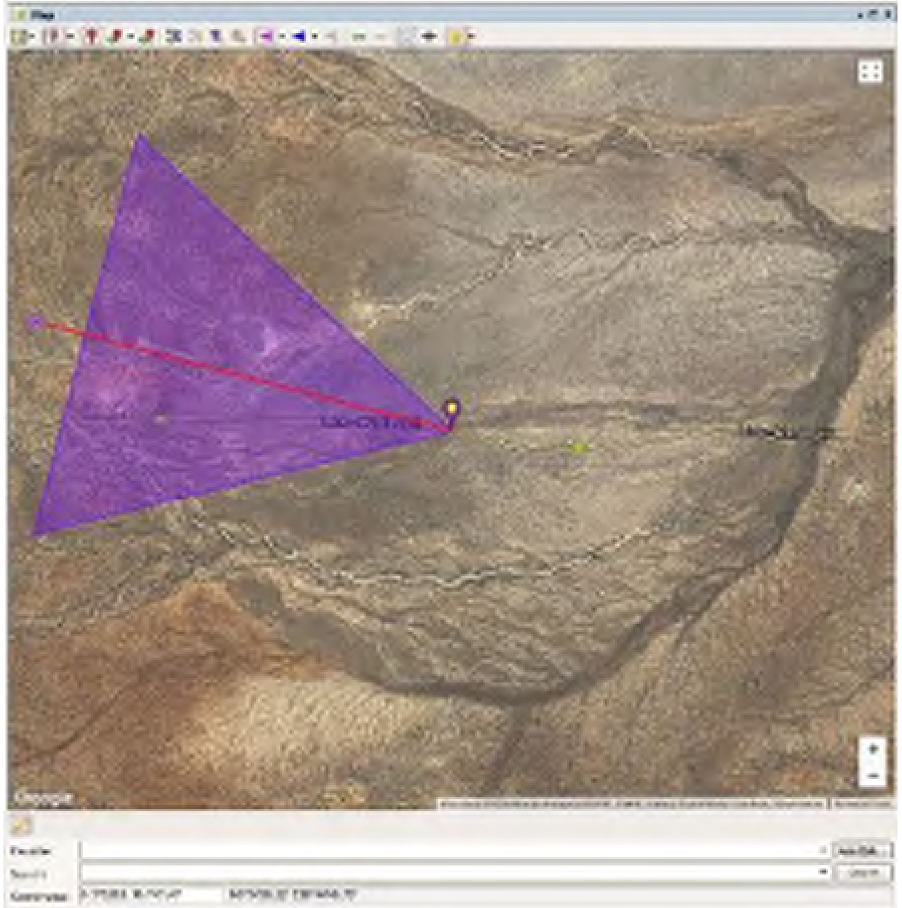
Point 16.



The area near Kachuru village is generally flat and water flows on a wide section as indicated by the wide sandy river bed.

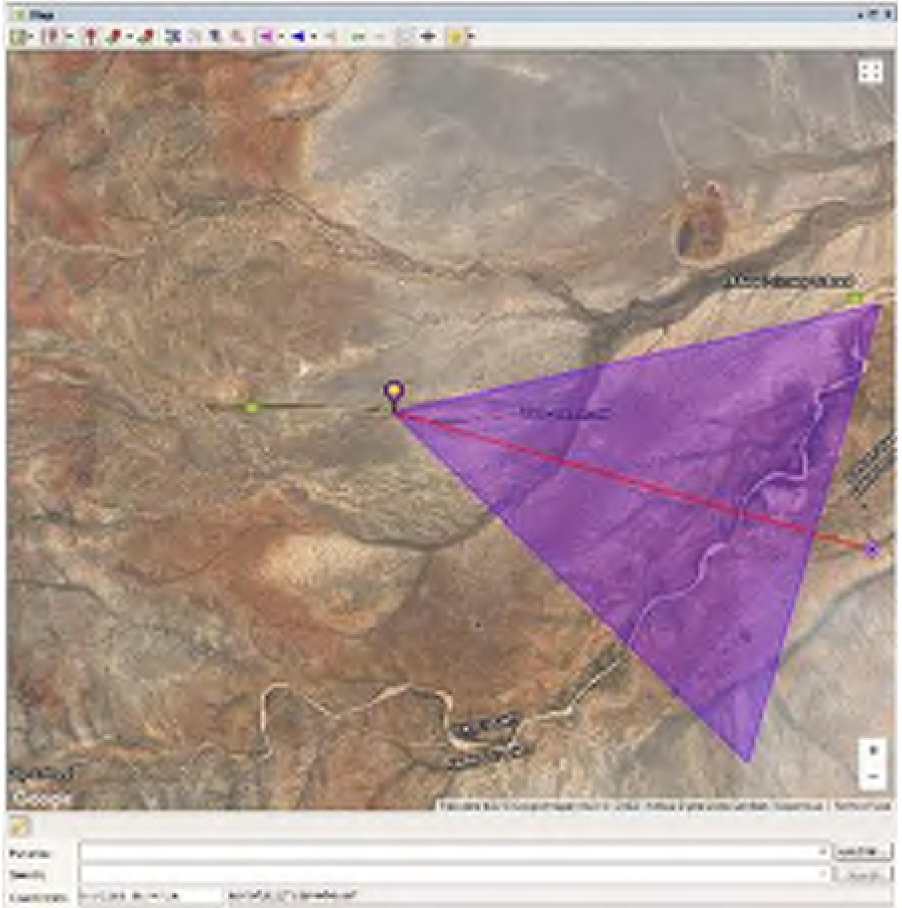
Description: Backward view at an approach to a water crossing but with no drainage structure.
Coordinates: N0°34'20.22" E38°44'49.73"
Altitude: 400.4m

Point 17



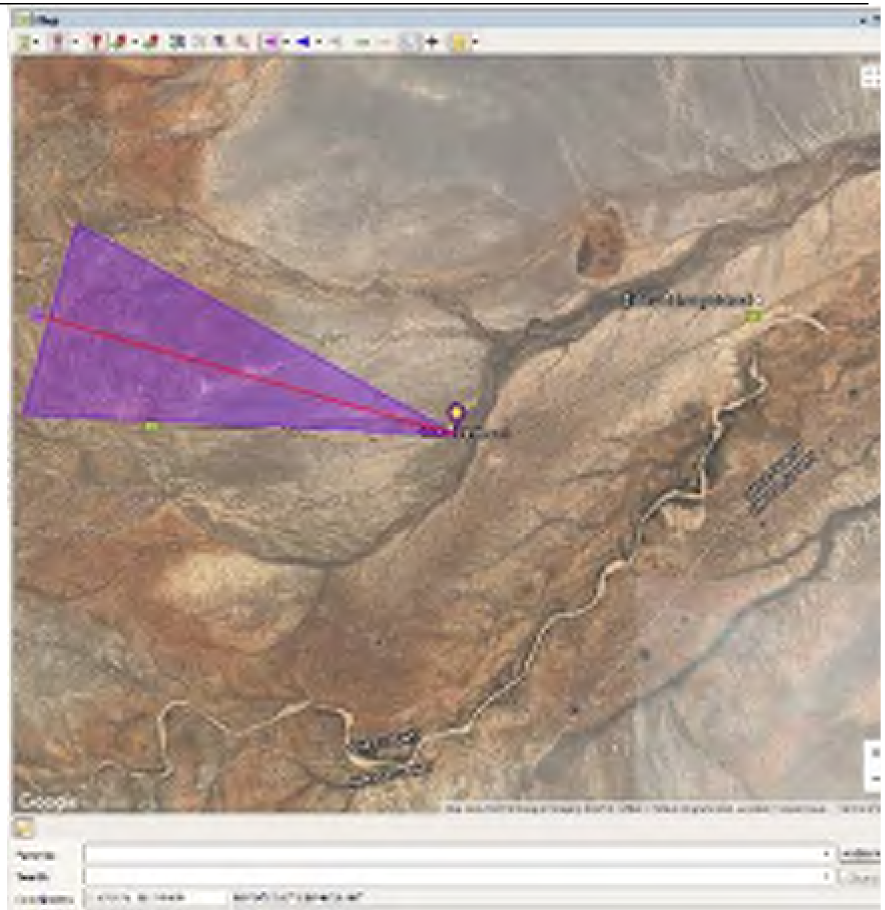
Description: Forward view at an approach to a water crossing but with no drainage structure.
Coordinates: N0°34'20.22" E38°44'49.69"
Altitude: 401.8m

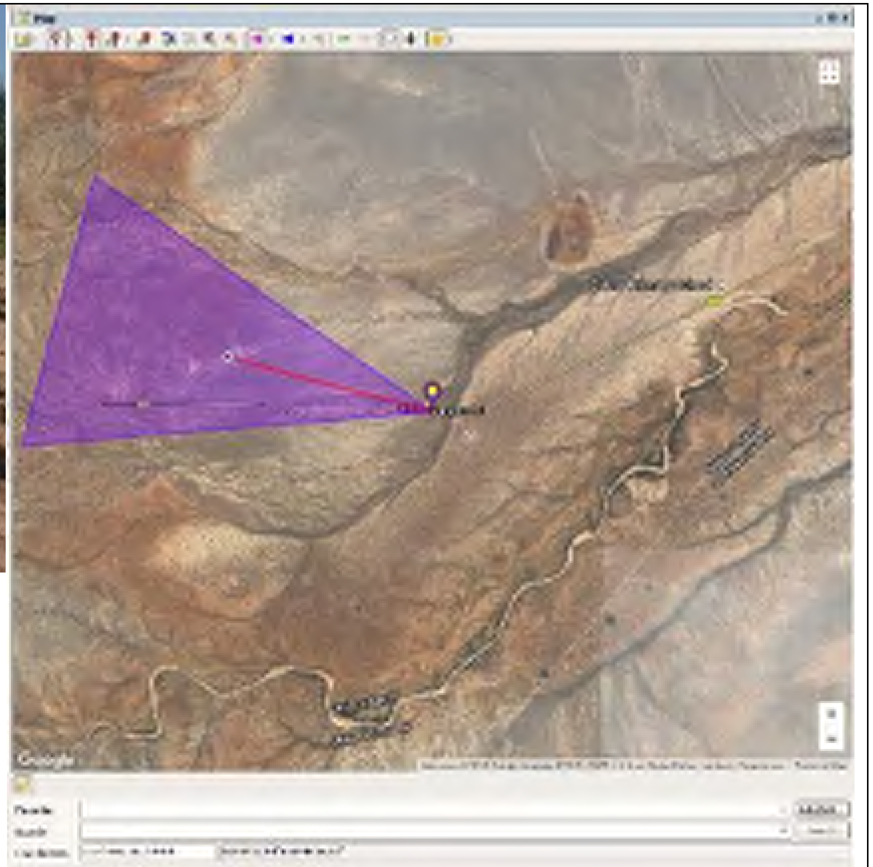
Point 17



Description: Forward view at an approach to a water crossing but with no drainage structure. Section filled with sand.
Coordinates: N0°34'17.67" E38°46'36.98"
Altitude: 383.5m

Point 18



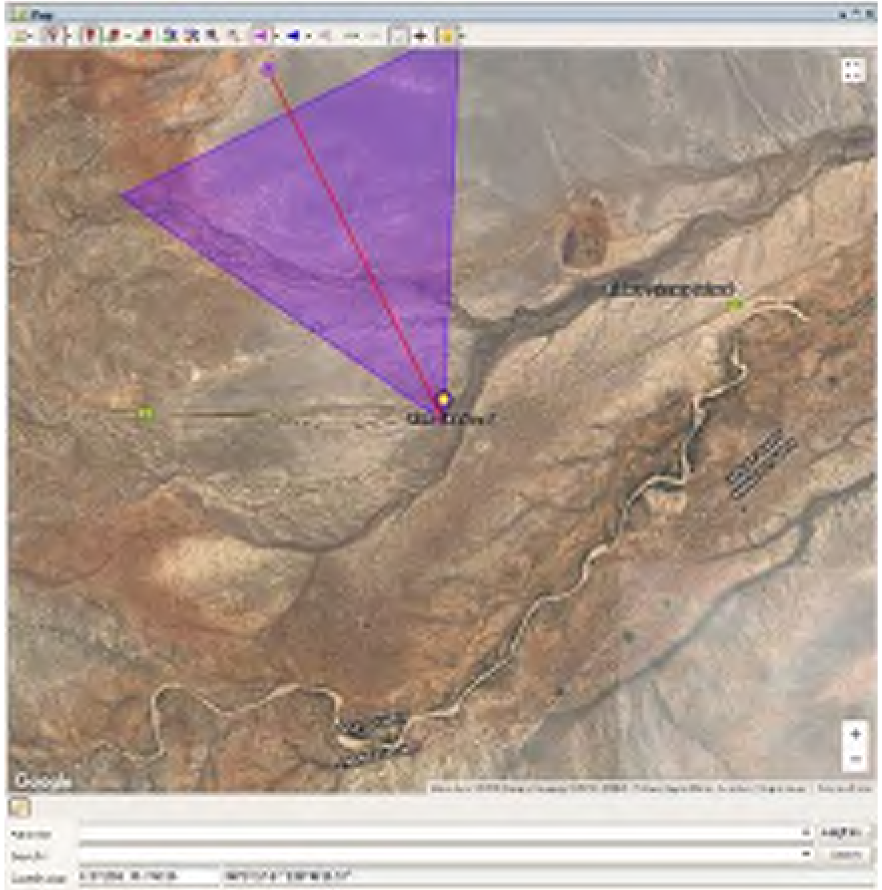


Description: Sandy road section before a drift. The section becomes impassable during the wet season as the vehicles get stuck in the sand.
Coordinates: N0°34'17.64" E38°46'36.97"
Altitude: 359.0m

Point 18

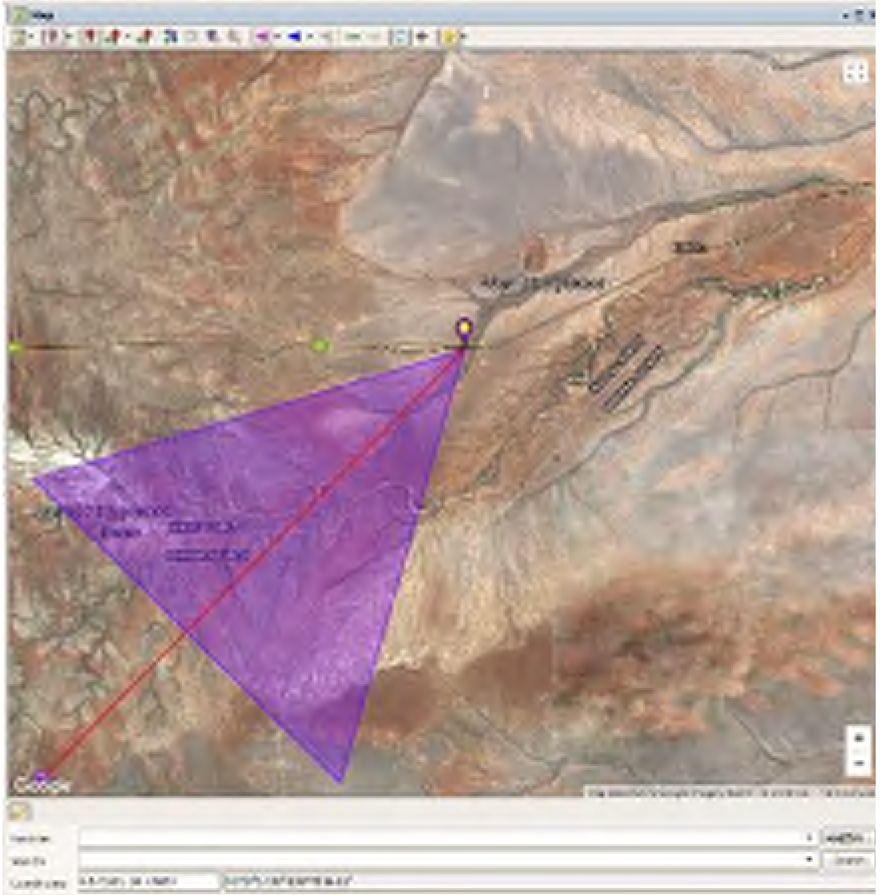
Description: Upstream view on the lhs of the water crossing the road.
Coordinates: N0°34'17.64" E38°46'36.97"
Altitude: 291.18m

Point 18



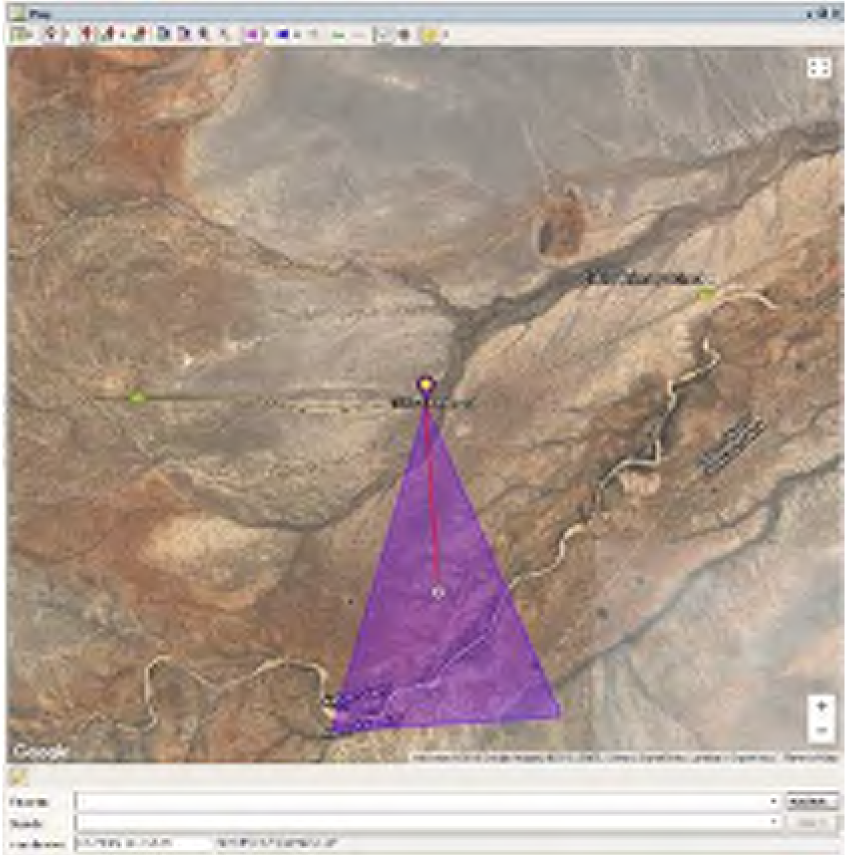
Description: Downstream view on the rhs of the water crossing the road.
Coordinates: N0°34'17.69" E38°46'36.83"
Altitude: 383.8m

Point 18



Description: Lhs view of a silted culvert, immediately after the long drift.
Coordinates: N0°34'17.97" E38°46'37.28"
Altitude: 354.0m

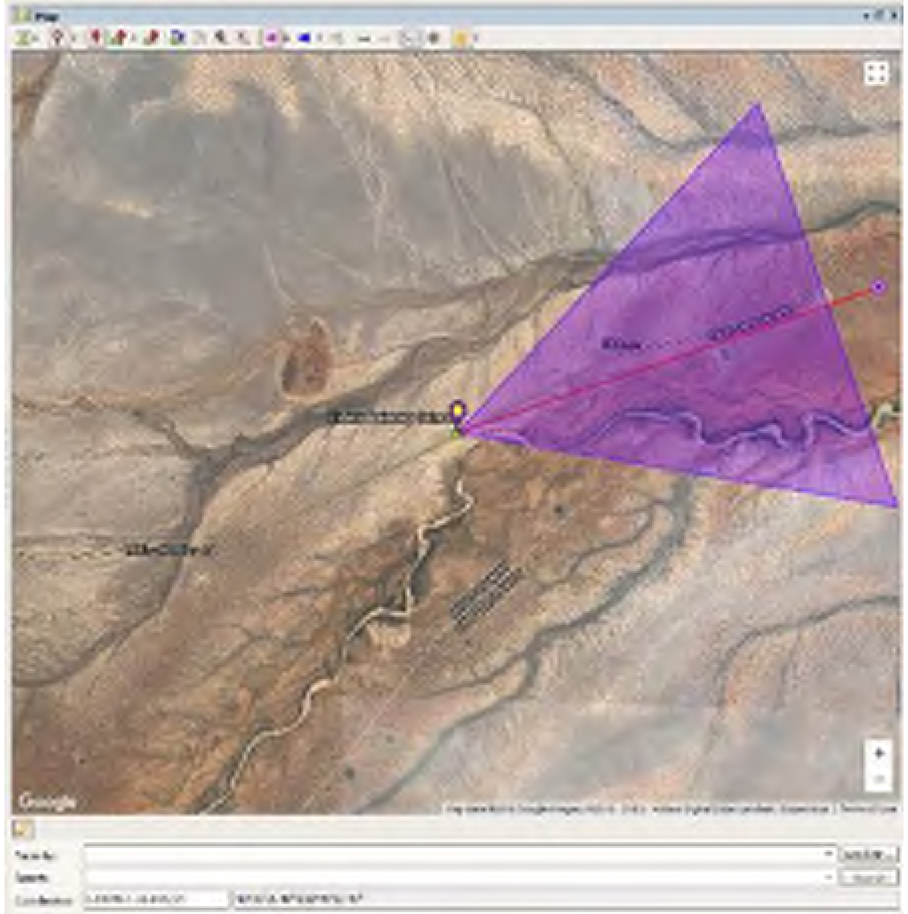
Point 18



Drift section is about 150m long but water crosses on a width of about 200m. There is also a 900mm diameter twin culvert that is half silted. The sandy riverbed is pronounced on both the upstream and downstream

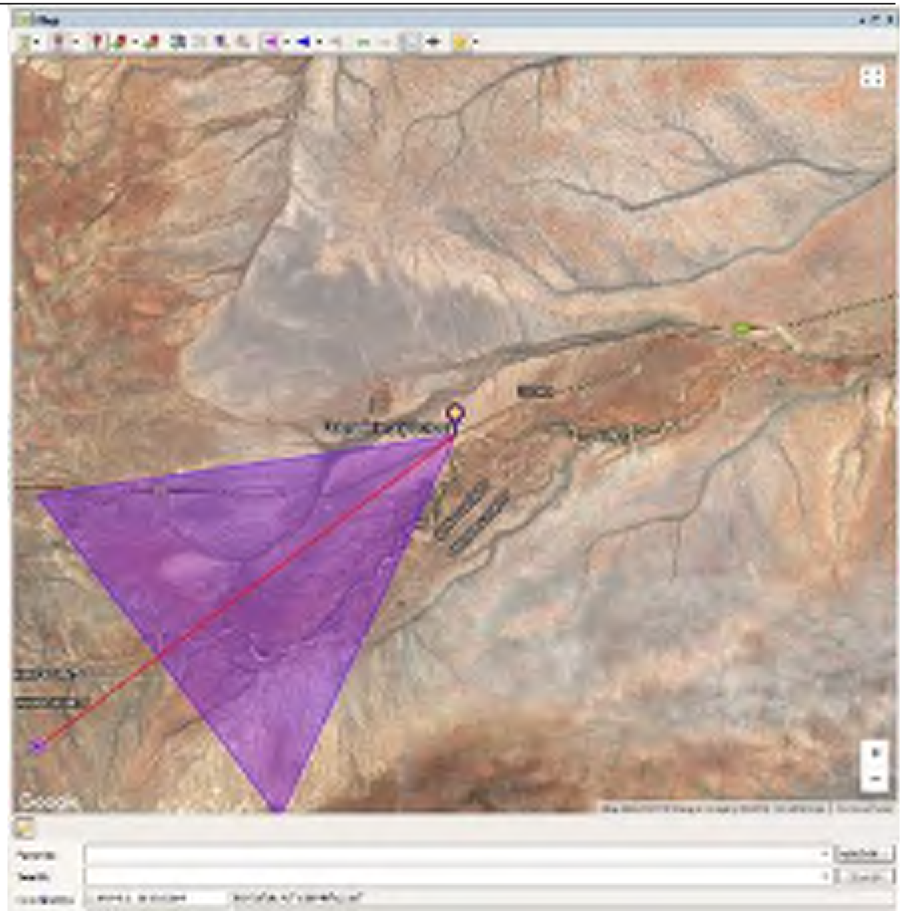
Description: Forward view on the rhs of the water Channel flowing along the road to a culvert.
Coordinates: N0°35'36.48" E38°49'52.43"
Altitude: 366.9m

Point 19



Description: Backward view on the rhs, of water flowing on the side of the road to enter a culvert. The water flowing along the road has scoured the side of the road making it narrow.
Coordinates: N0°35'36.43" E38°49'52.55"
Altitude: 368.4m

Point 19

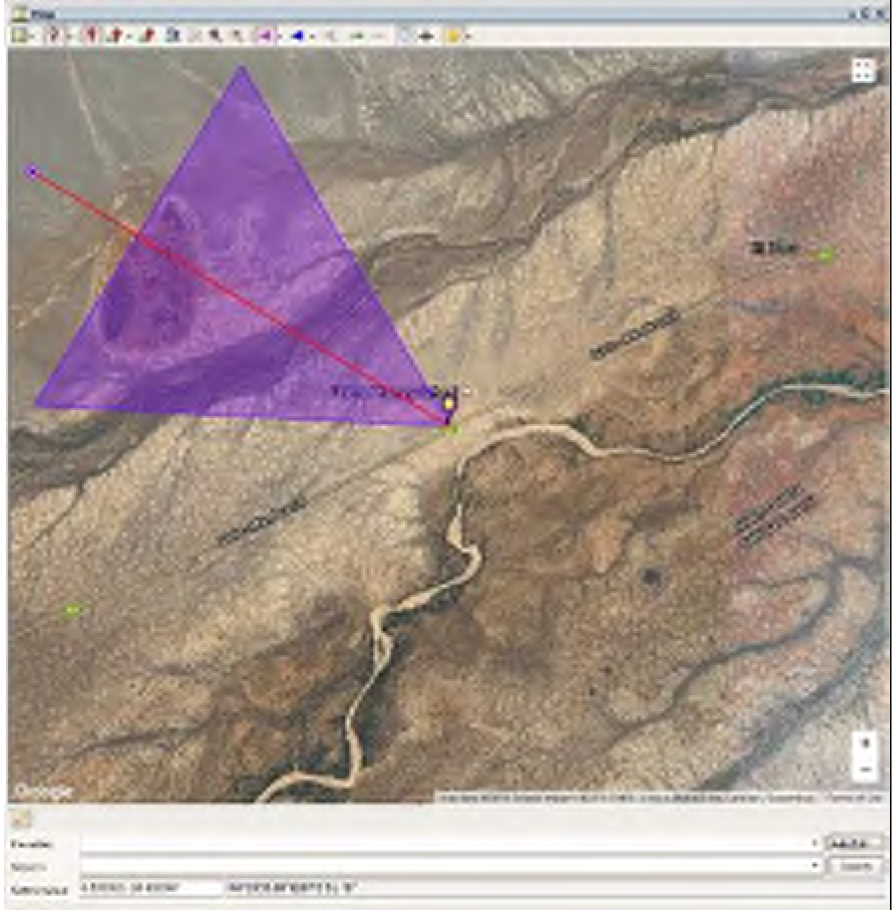


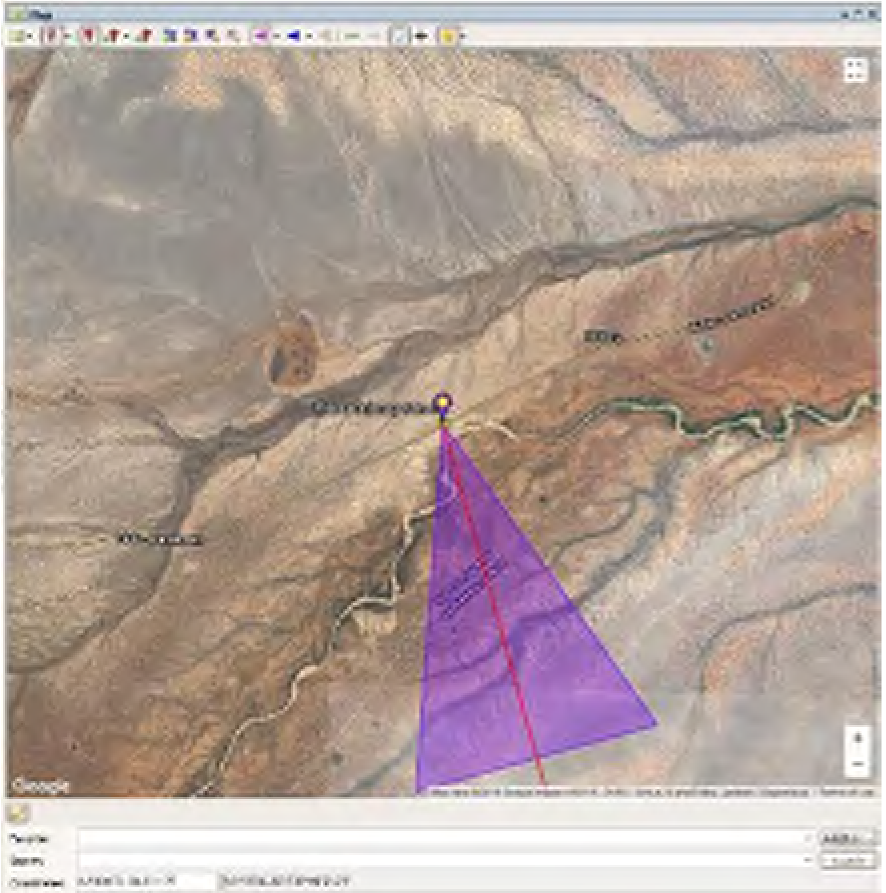
Description: Approach to a 900mm diameter cross culvert.
Coordinates: N0°35'36.17" E38°49'51.80"
Altitude: 362.7m

Point 20

Description: Flat area on the lhs of a culvert.
Coordinates: N0°35'35.88" E38°49'51.48"
Altitude: 364.4m

Point 20



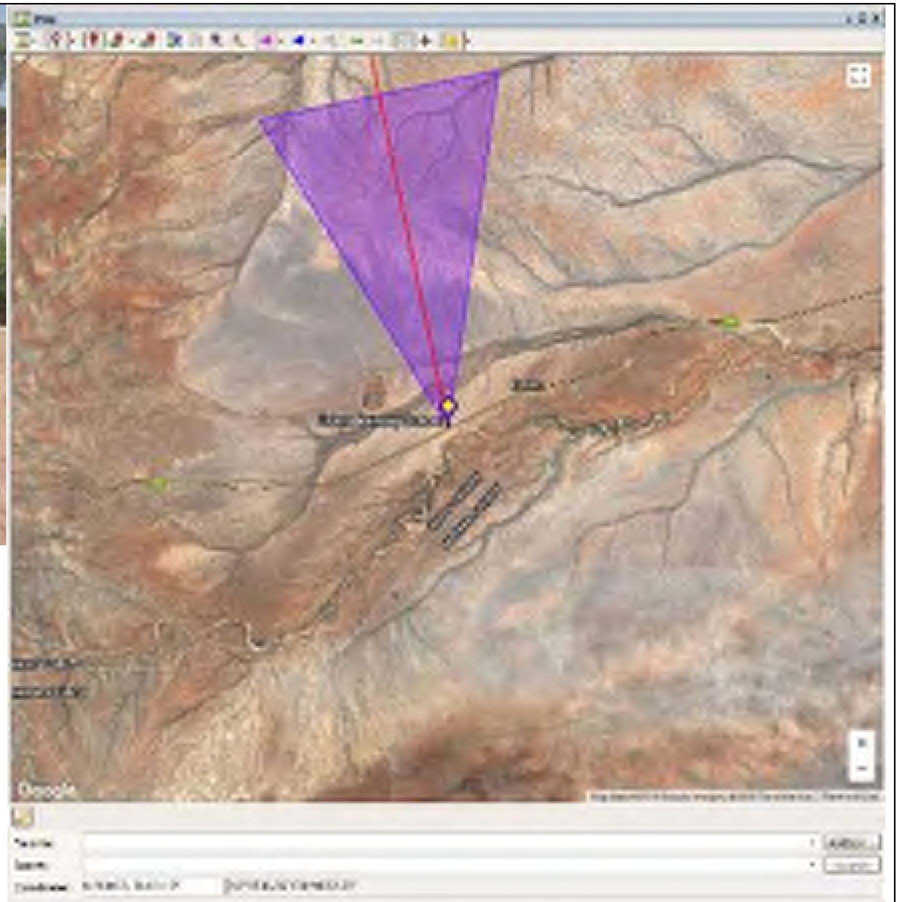


Description: Inlet on the lhs of a culvert, with no siltation and also no signs of overtopping.
Coordinates: N0°35'36.36" E38°49'52.23"
Altitude: 329.0m

Point 20

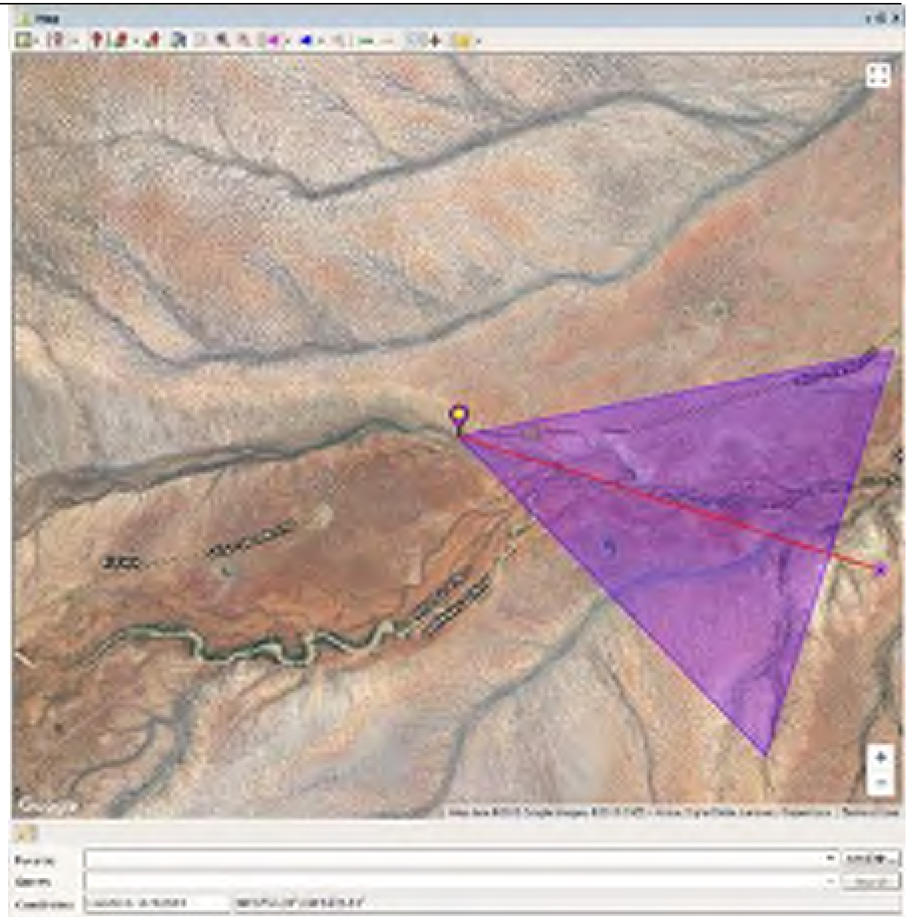
Description: Sandy outlet on the rhs of a 900mm diameter pipe culvert.
Coordinates: N0°35'36.36" E38°49'52.23"
Altitude: 329.0m

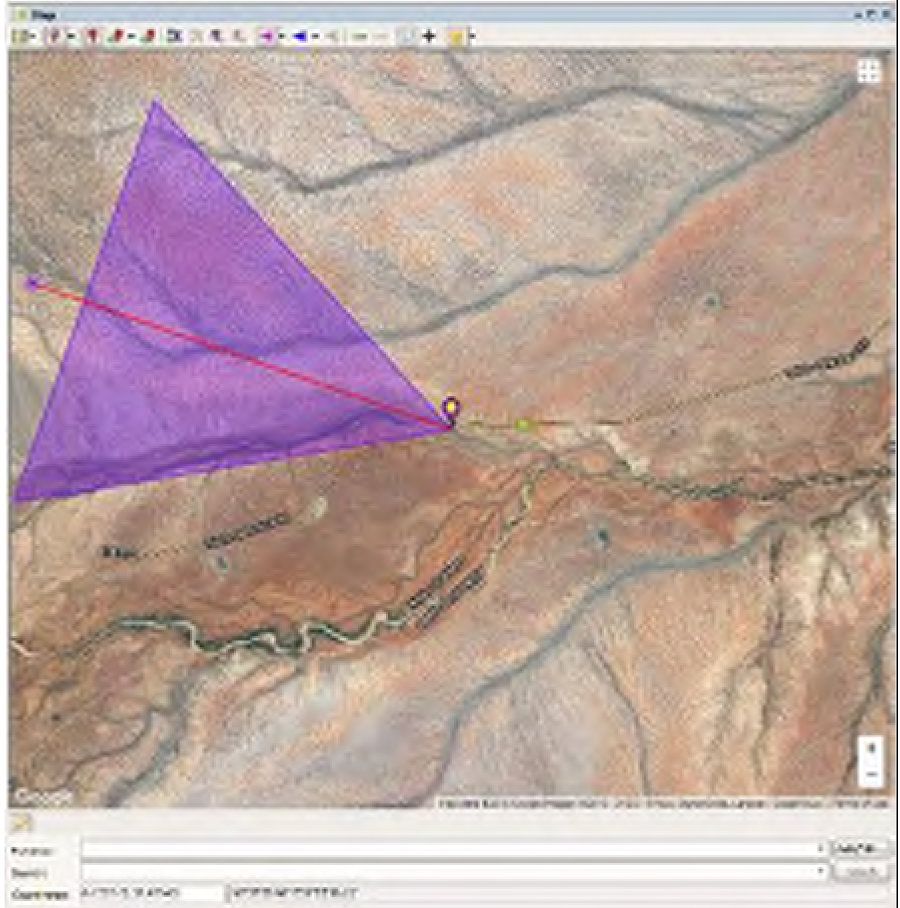
Point 20.

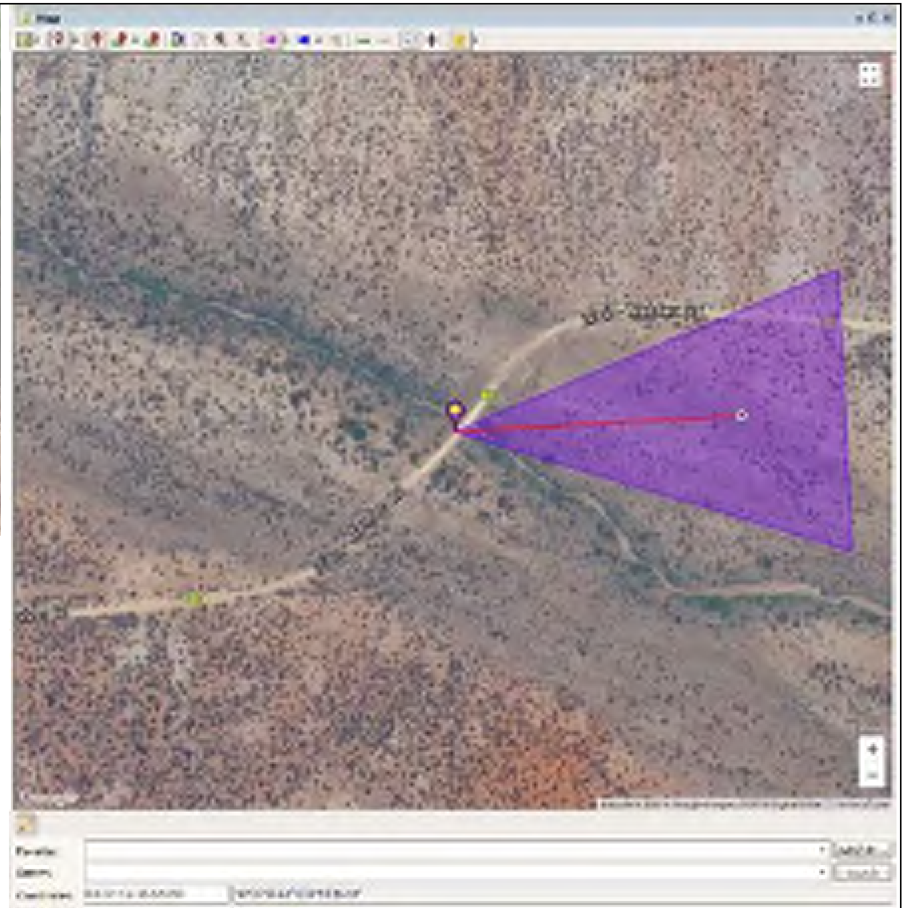


Description: Approach to a twin box culvert, The approach road contains fine sand that causes vehicles to get stuck during the wet season.
Coordinates: N0°37'57.39" E38°55'21.61"
Altitude: 335.3m

Point 21



 Description: Upstream stream view on the lhs of the twin box culvert. Coordinates: N0°37'55.98" E38°55'20.66" Altitude: 338.7m Point 21	

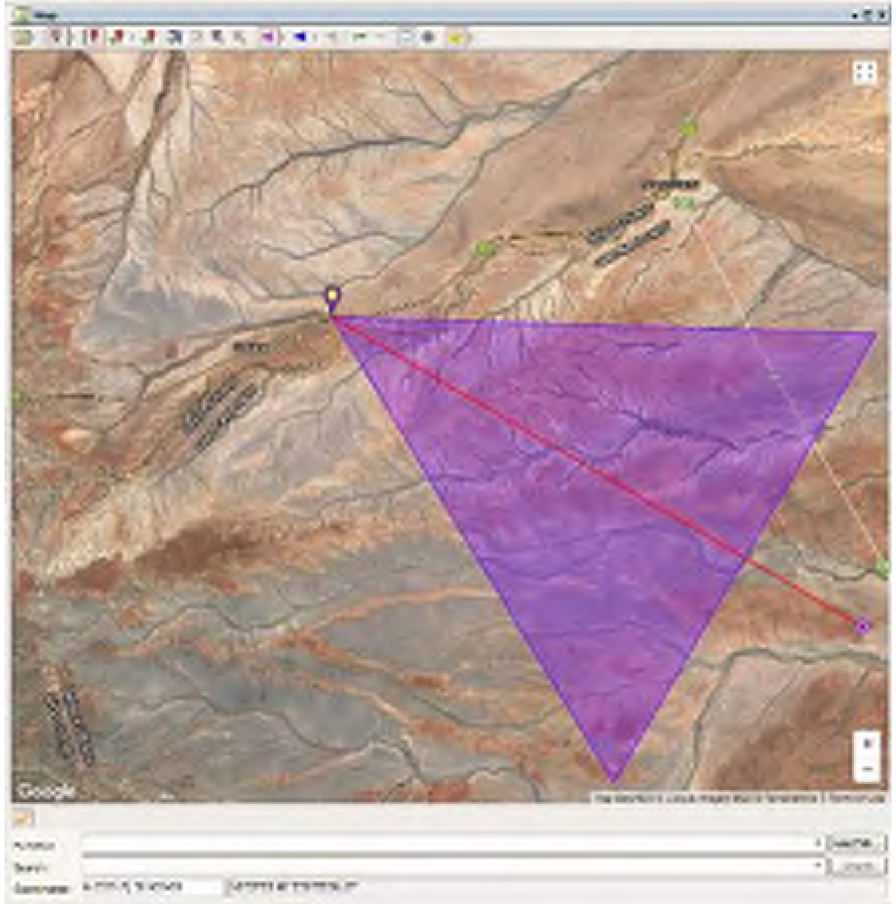


I Description: inlet view on the lhs of the twin box culvert with branches stuck at the culvert.
Coordinates: N0°37'55.61" E38°55'20.14"
Altitude: 313.0m

Point 21

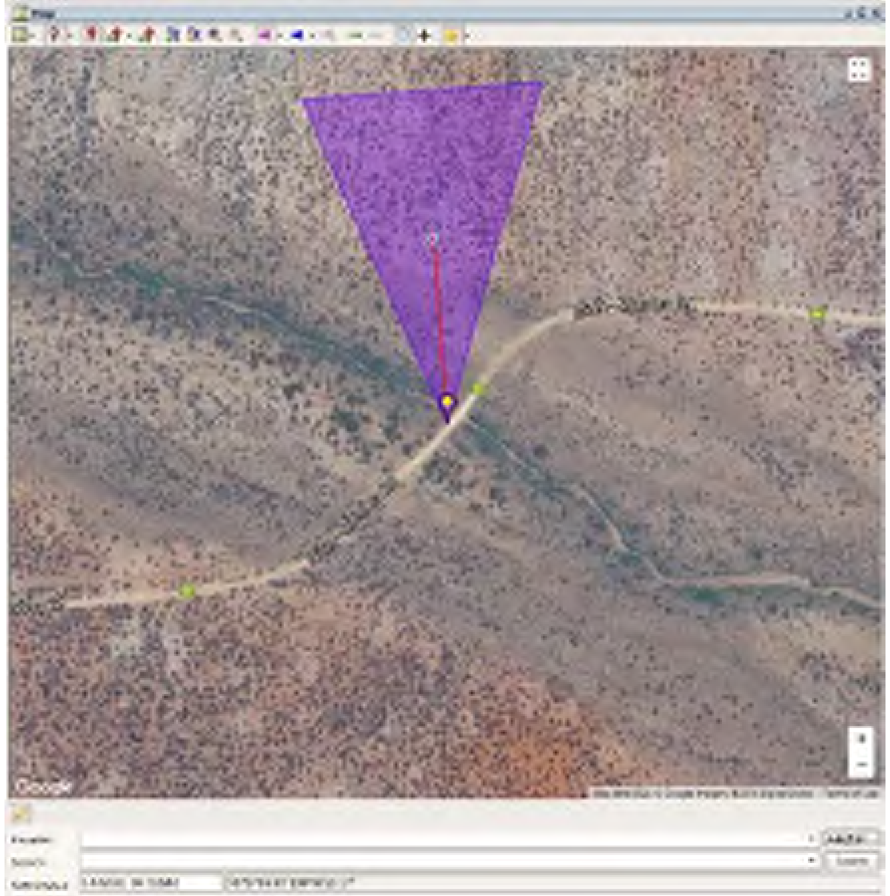
Description: Downstream view on the rhs of the twin box culvert with scouring of about3m deep.
Coordinates: N0°37'55.98" E38°55'20.67"
Altitude: 342.8m

Point 21



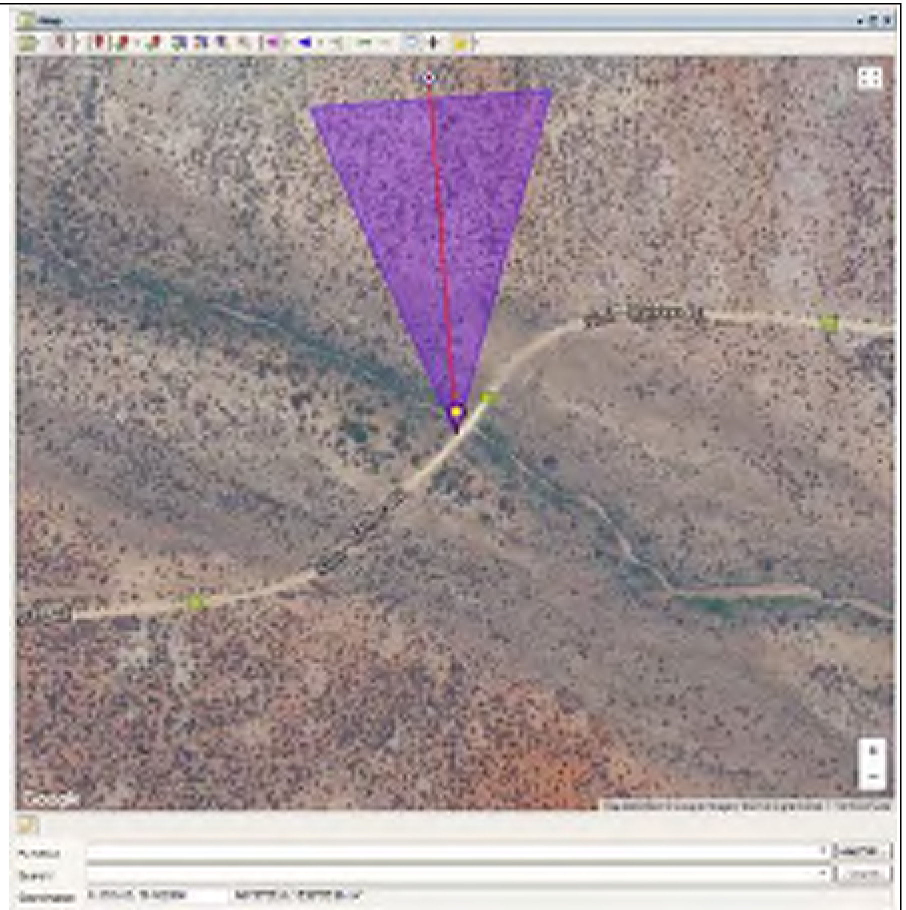
Description: Culvert outlet view on the rhs of the twin box culvert with gabion protection works.
Coordinates: N0°37'55.61" E38°55'20.14"
Altitude: 313.0m

Point 21



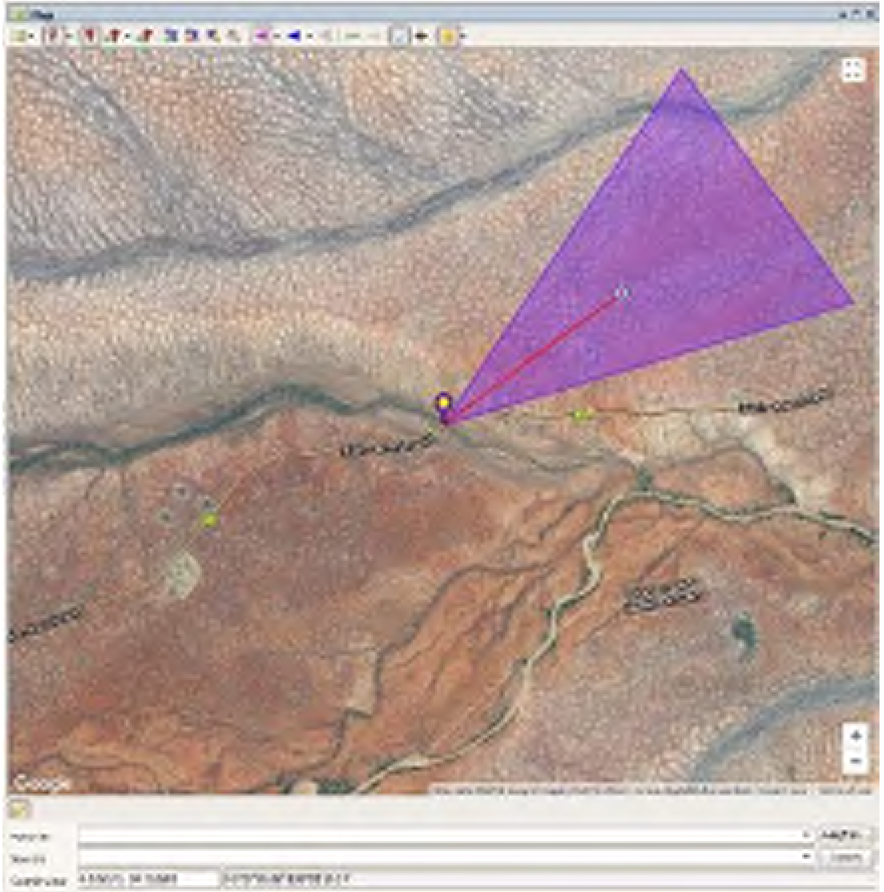
Description: Protection works on culvert outlet, undermined by the storm water.
Coordinates: N0°37'55.61" E38°55'20.14"
Altitude: 313.0m

Point 21

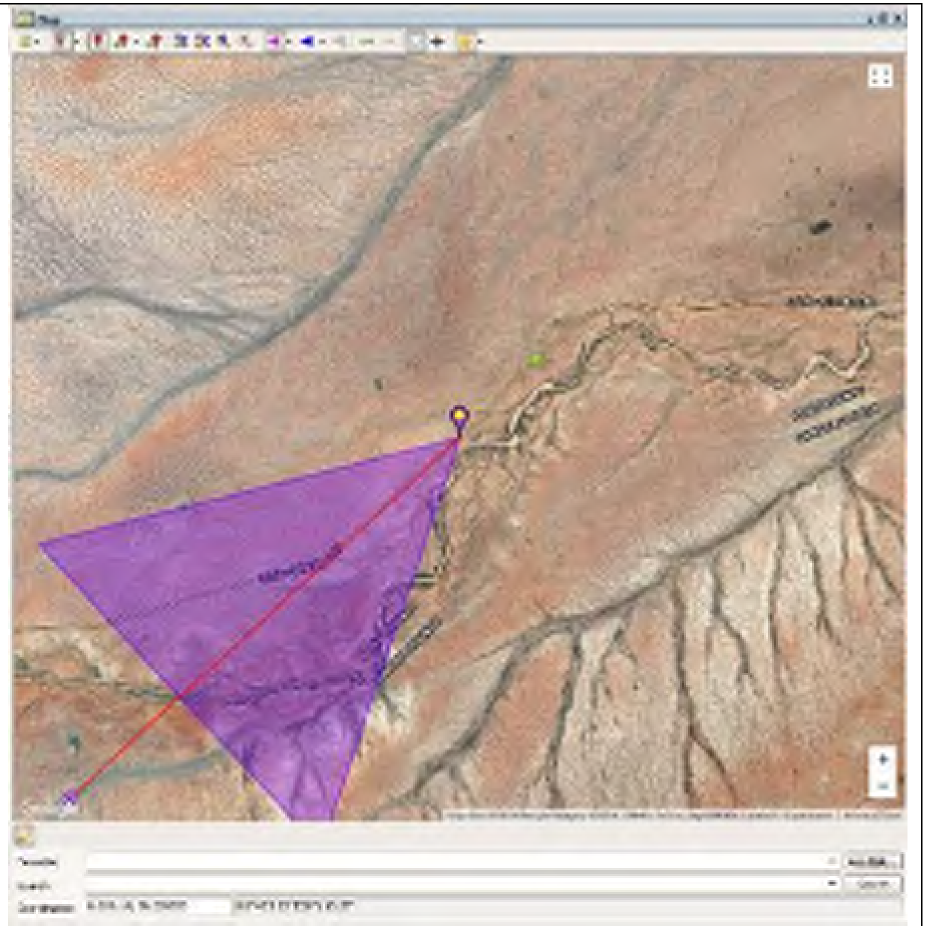


Description: Forward approach view to the twin box culvert.
Coordinates: N0°37'55.82" E38°55'19.94"
Altitude: 297.0m

Point 21

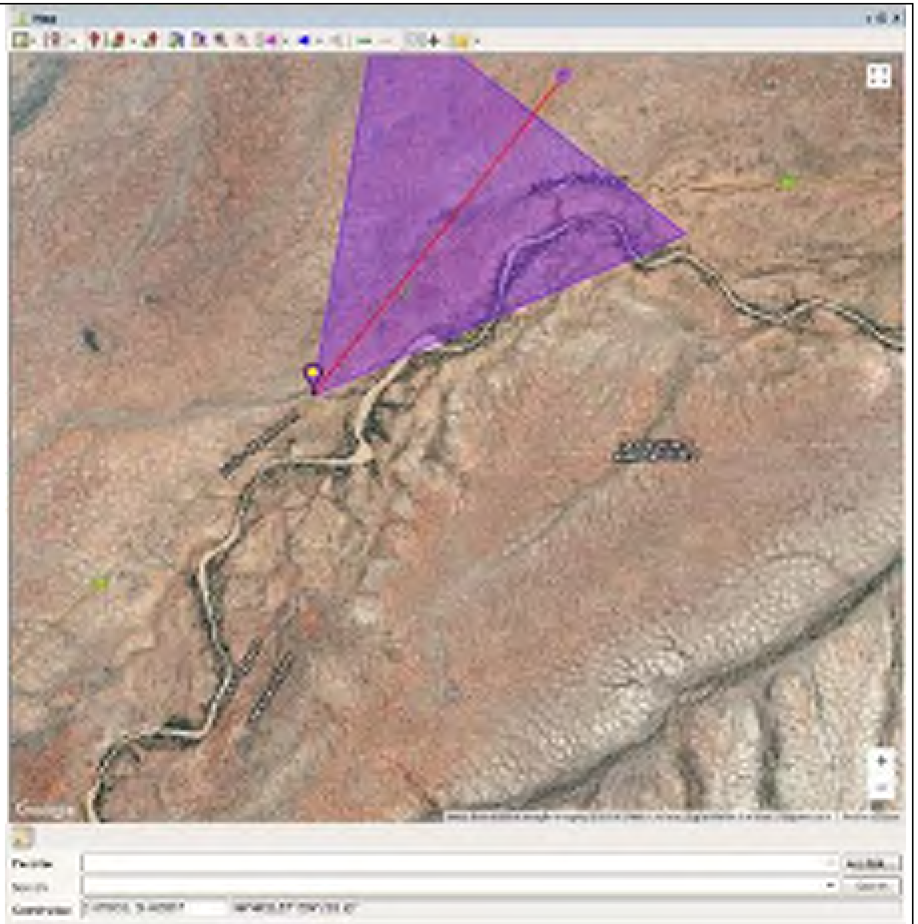


The twin box culvert shows no signs of silting, but shows possible overtopping, since the gabions have been undermined by the storm water.

 Description: Back ward view of the Gravel road at a flat area on both sides of the road Coordinates: N0°40'5.23" E39°1'13.27" Altitude: 304.0m Point 22	

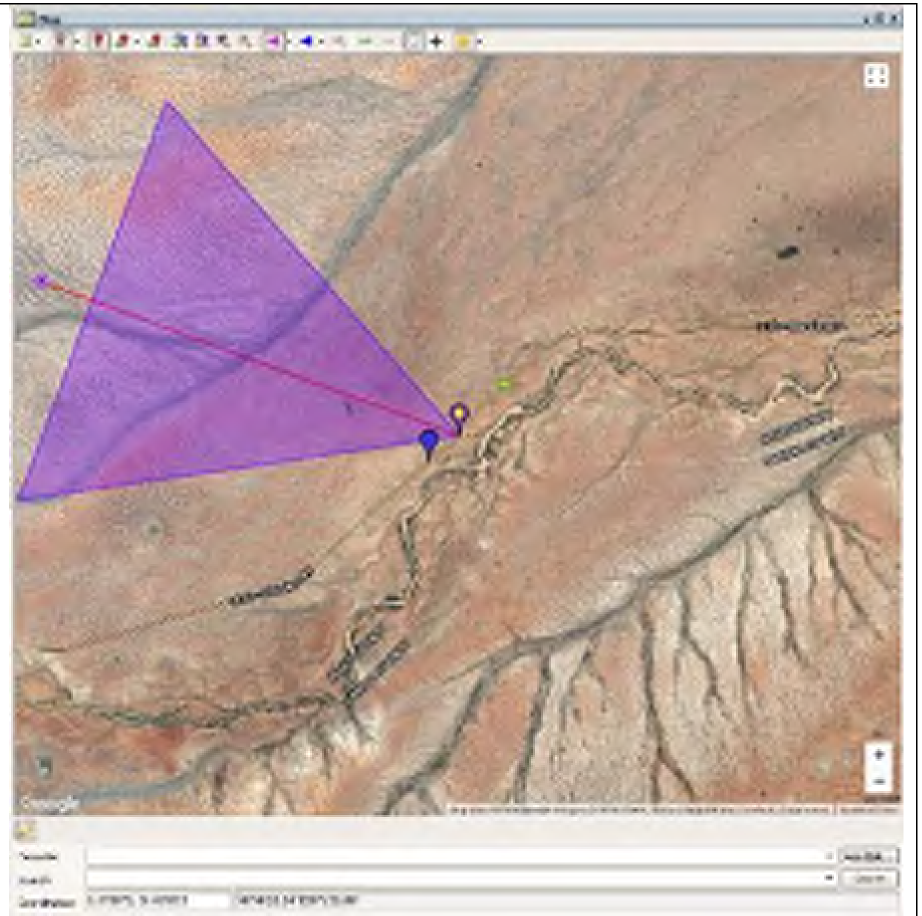
Description: Forward view of approach to a drift crossing.
Coordinates: N0°40'22.57" E39°1'33.12"
Altitude: 304.2m

Point 23



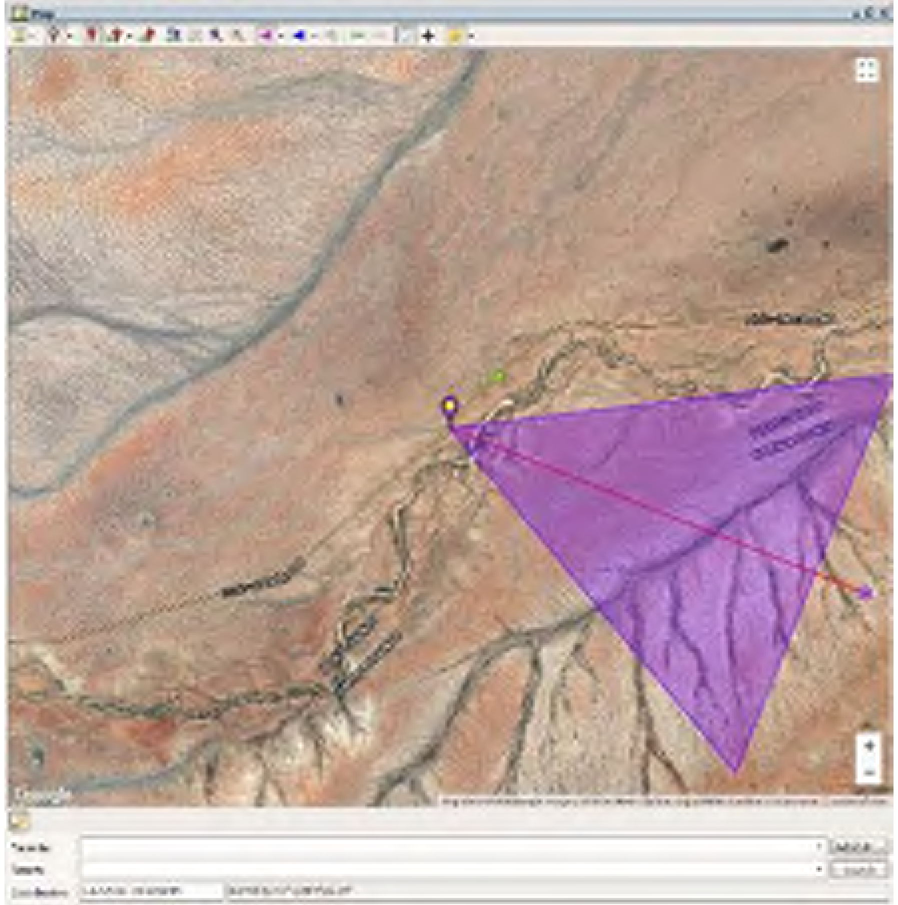
Description: Upstream view on the rhs of the drift with sand deposits.
Coordinates: N0°40'22.34" E39°1'32.89"
Altitude: 300.0m

Point 23



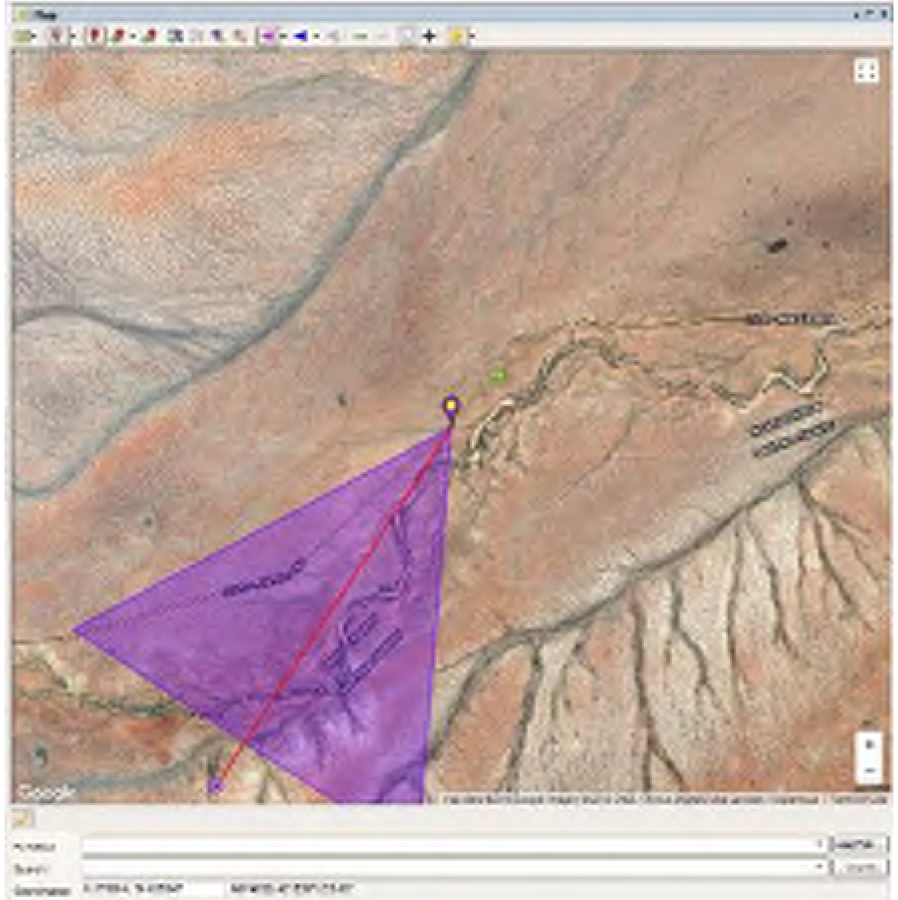
Description: Downstream view on the lhs of the drift, with signs of scouring.
Coordinates: N0°40'22.47" E39°1'33.04"
Altitude: 300.0m

Point 23



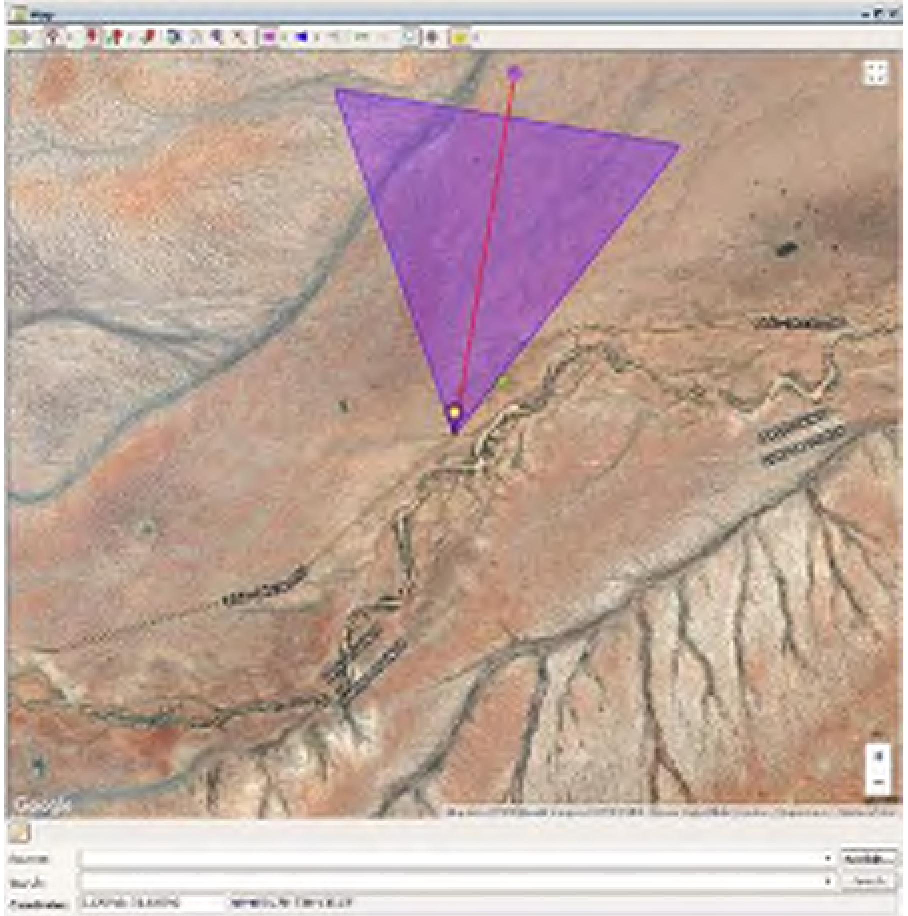
Description: Rhs of the drift showing signs of failure.
Coordinates: N0°40'22.42" E39°1'33.05"
Altitude: 300.1m

Point 23



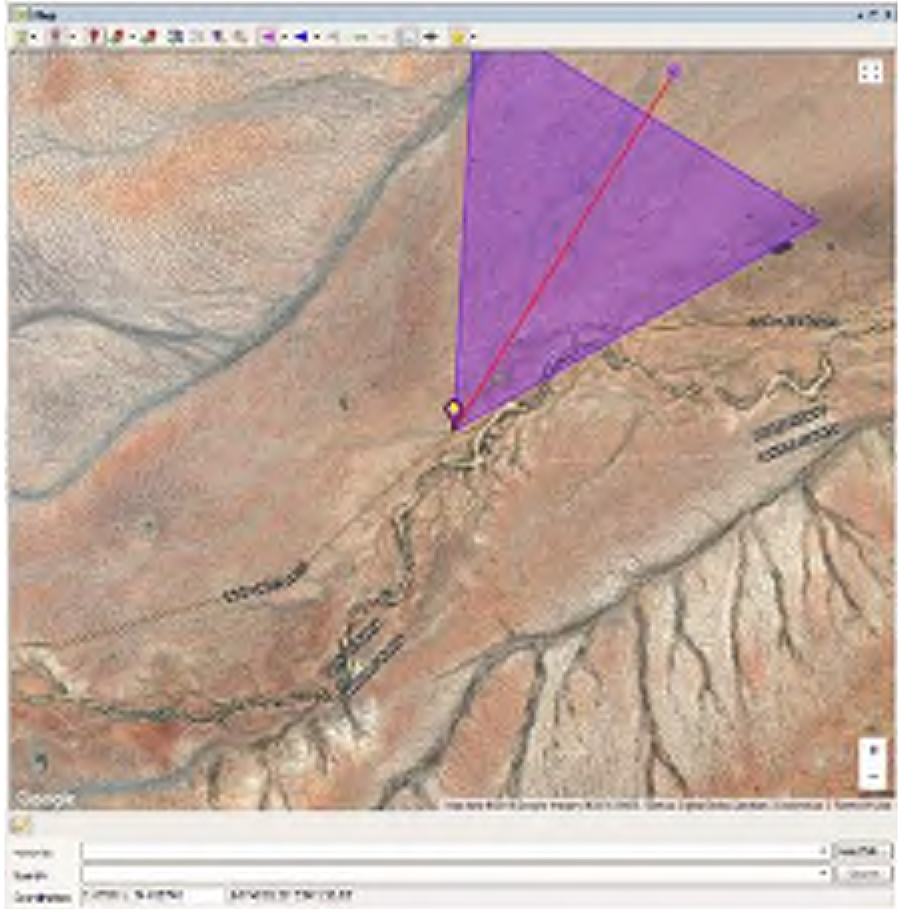
Description: Rhs of the drift showing signs of failure.
Coordinates: N0°40'21.79" E39°1'32.67"
Altitude: 300.1m

Point 23



Description: Scouring on the outlet of the drift
Coordinates: N0°40'21.79" E39°1'32.67"
Altitude: 300.1m

Point 23

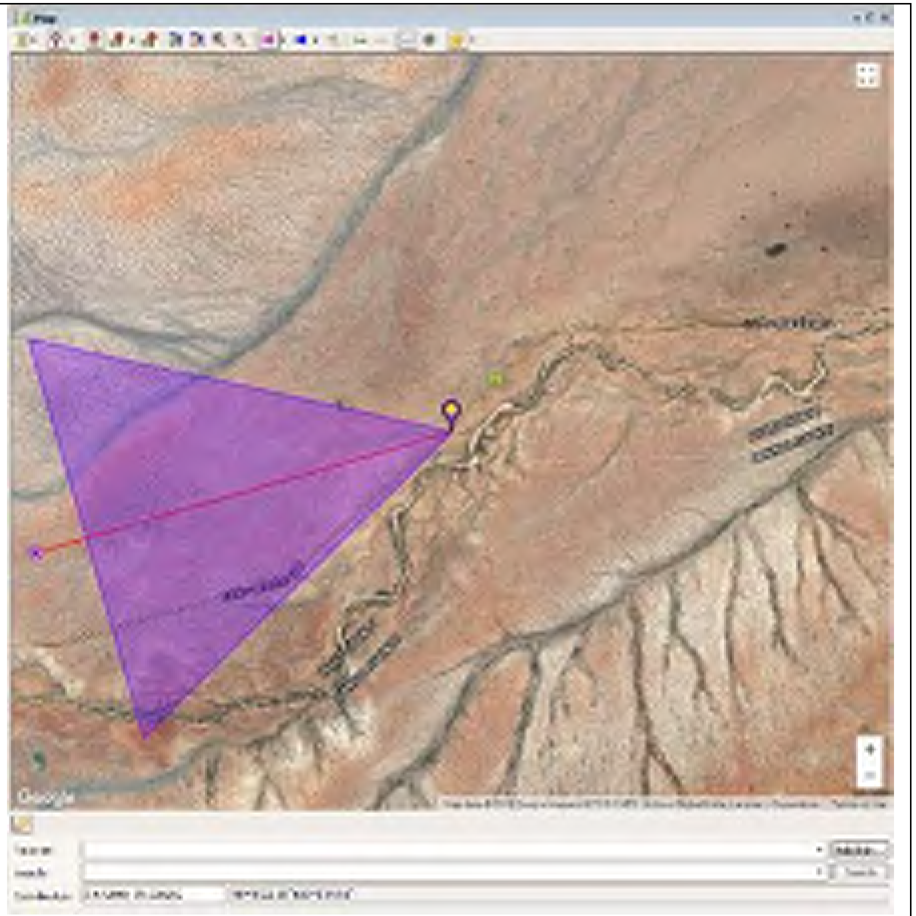


The drift location has experienced several previous washouts due to heavy rains. The waters affecting this section are from a seasonal river flowing along the road on the rhs.

Backward view of Sand deposited on the road by rain water flowing along the road during the rainy season.

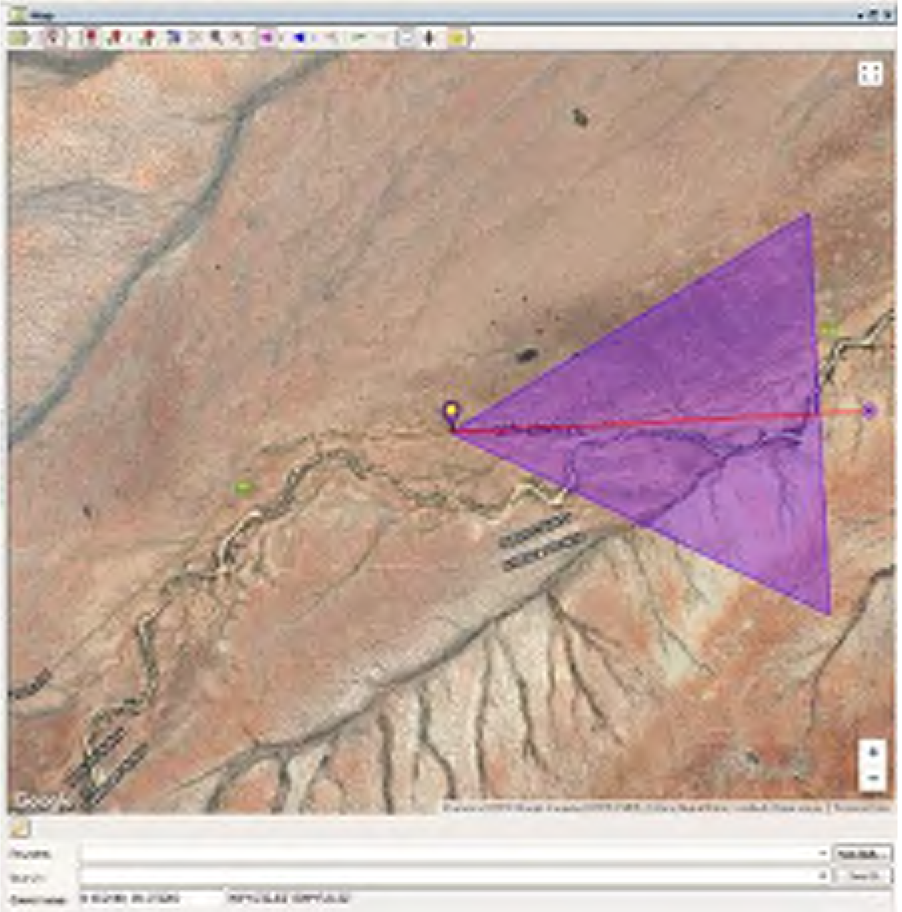
Coordinates: N0°40'22.30" E39°1'34.51"

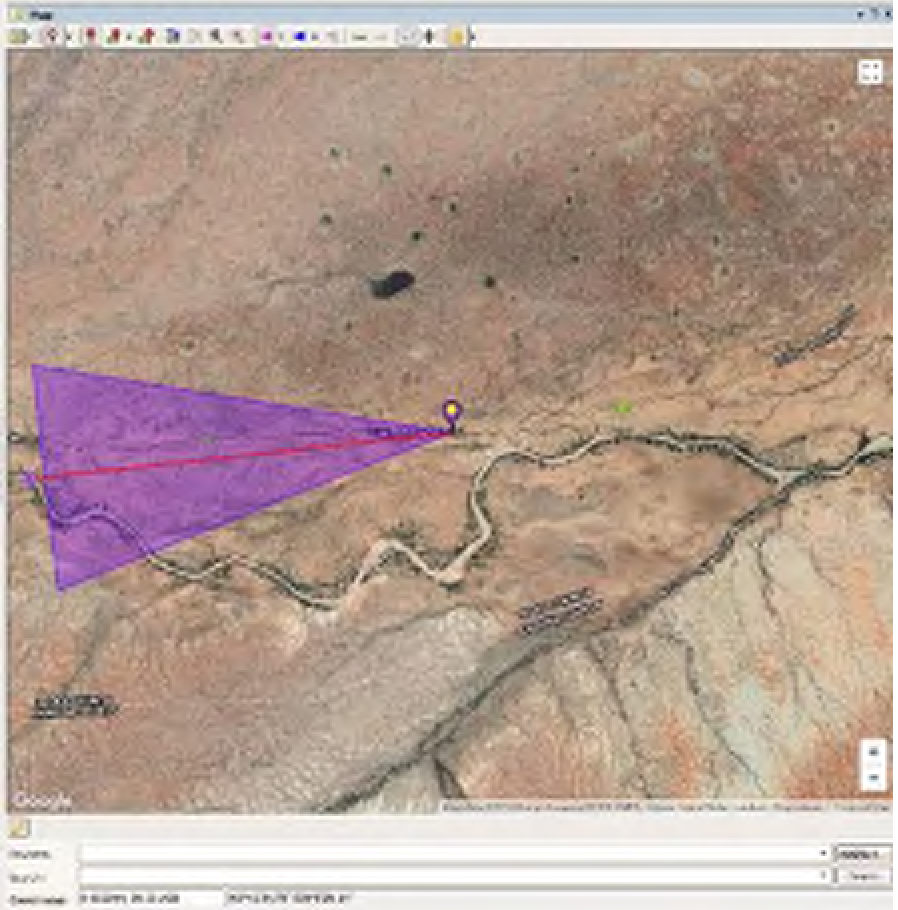
Altitude: 300.1m a.s.l



Description: Forward view of Sand deposited on the road by rain water flowing along the road during the rainy season.
Coordinates: N0°41'32.82" E39°4'19.92"
Altitude: 280.9m

Point 24

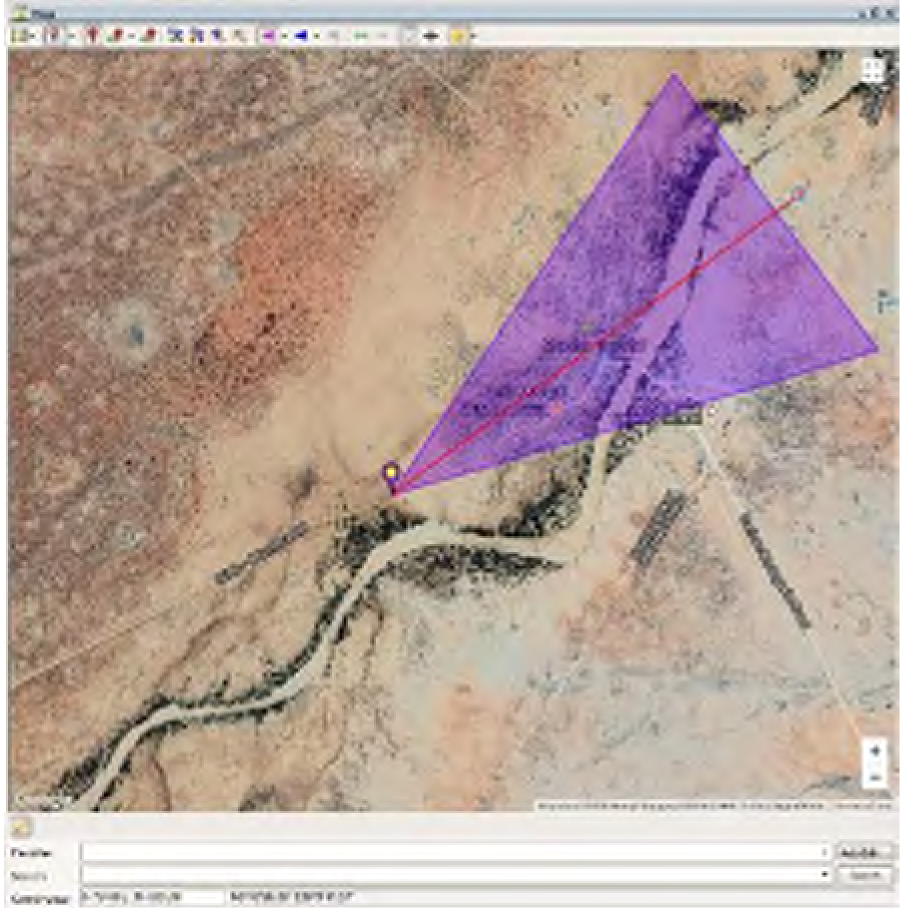


 Description: Sand deposited on the road side by rain water flowing along the road during the rainy season, and also eroding the gravel on the road. Coordinates: N0°41'32.82" E39°4'19.92" Altitude: 280.9m Point 25	

The sand deposited on the road stretches to a distance of about 300m

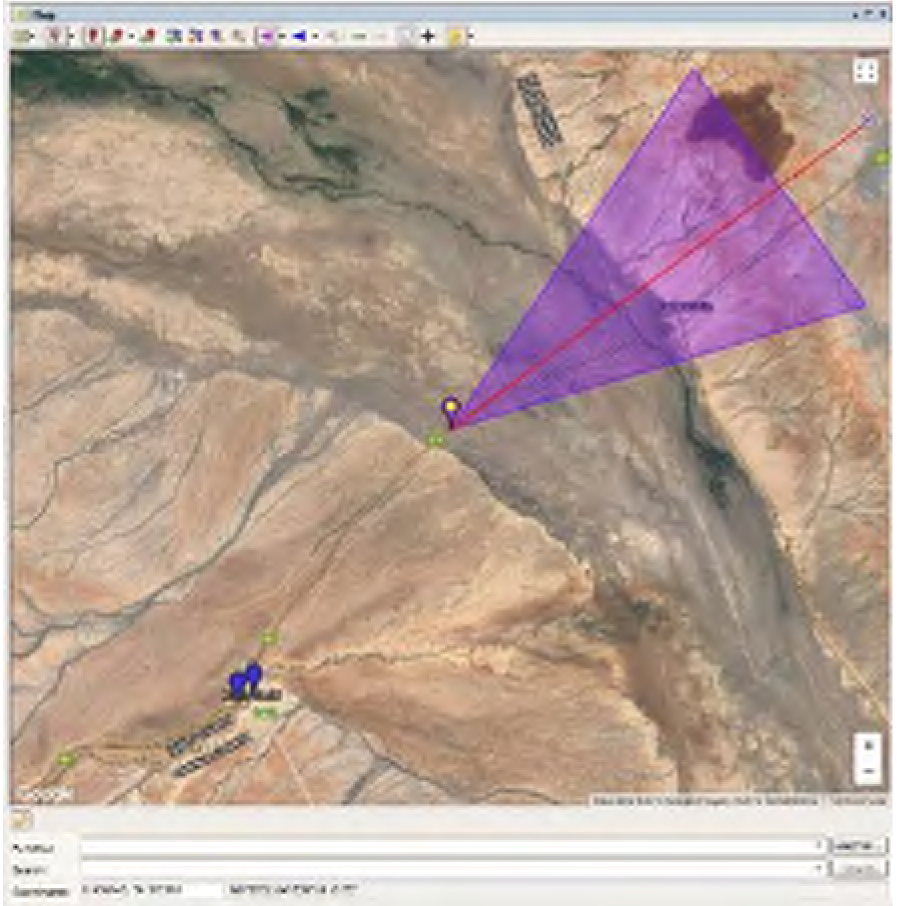
Description: Gravel road on a low area, approaching Modogashe. This is the approach to the Lorian swamp, which forms part of the Ewaso Ngiro River.
Coordinates: N0°41'32.82" E39°4'19.92"
Altitude: 280.9m

Point 26



Description: Forward view of the Gravel road at the start of the Ewaso Ngiro flood plains. The Ewaso Ngiro flood plain is about 25km and is part of the Lorian Swamp.
Coordinates: N0°55'36.64" E39°19'12.73"
Altitude: 207.0m

Point 27

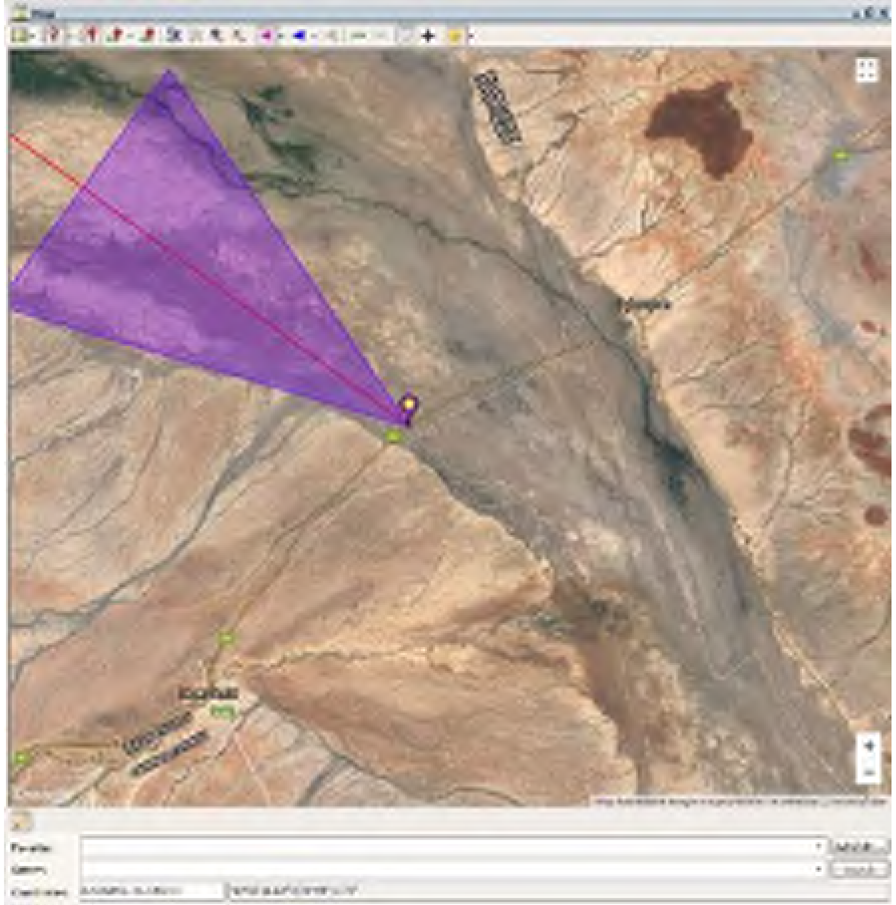


Description: Rhs view of the Ewaso Ngiro flood plains.
Coordinates: N0°55'36.64" E39°19'12.73"
Altitude: 207.0m

Point 27

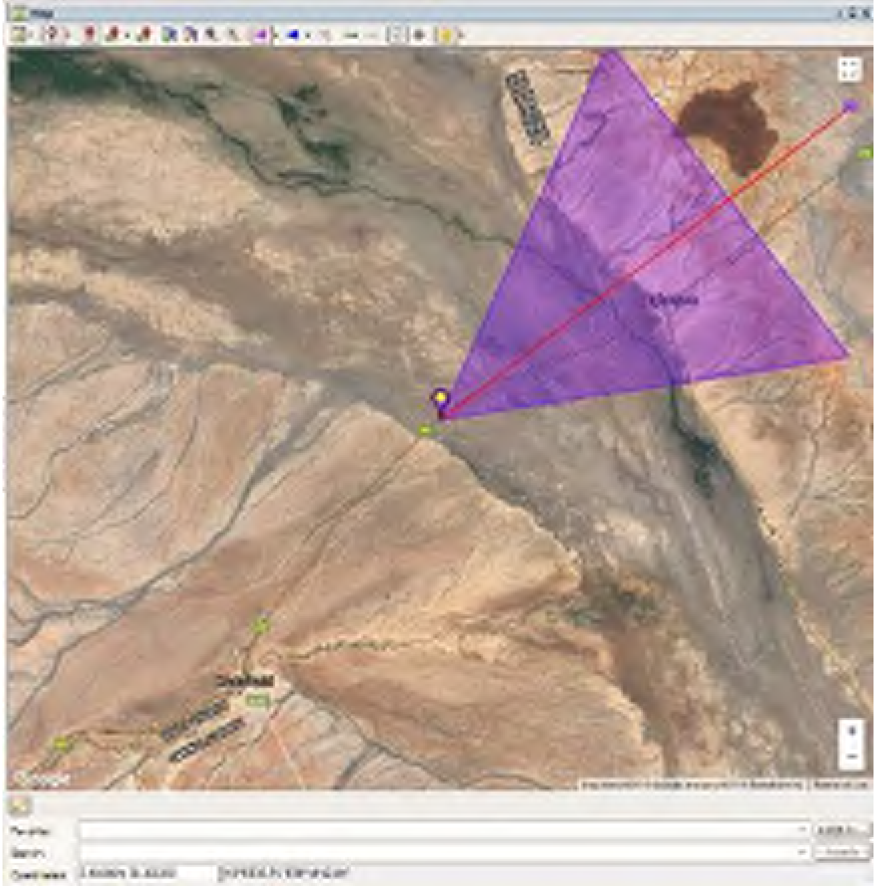
Description: Lhs view of the Ewaso Ngiro flood plains.
Coordinates: N0°55'36.64" E39°19'12.73"
Altitude: 207.0m

Point 27



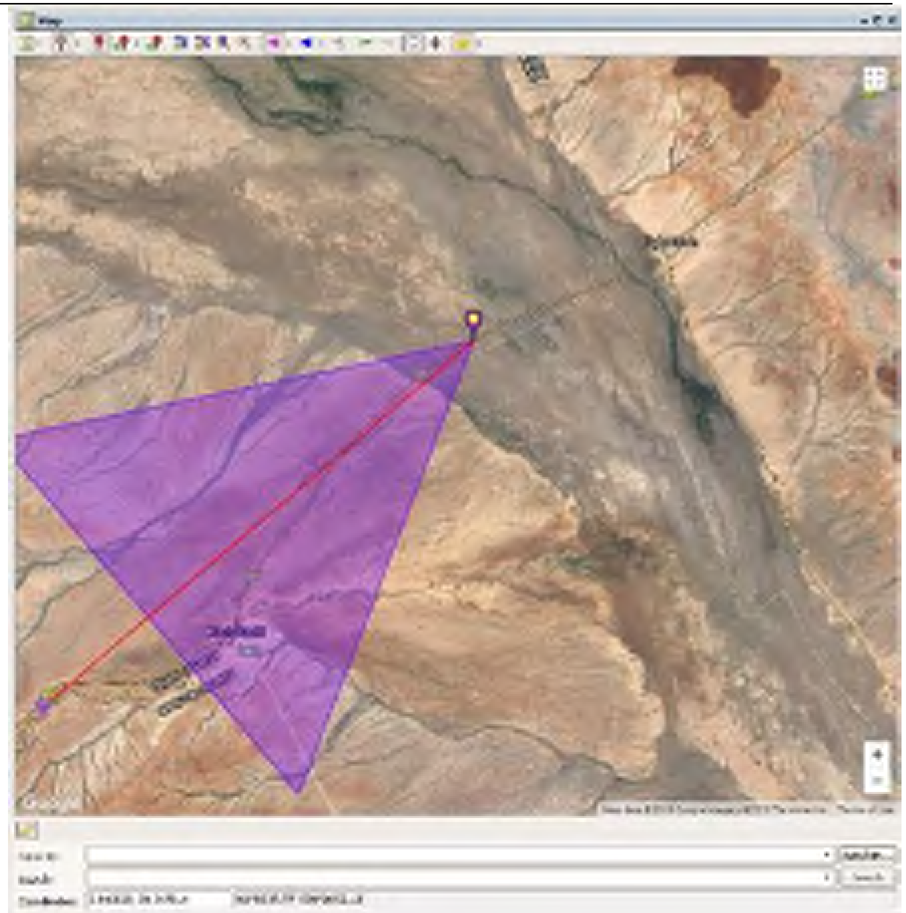
Description: Backward view of the gravel road at the Ewaso Ngiro flood plains.
Coordinates: N0°55'36.71" E39°19'12.84"
Altitude: 215.6m

Point 27



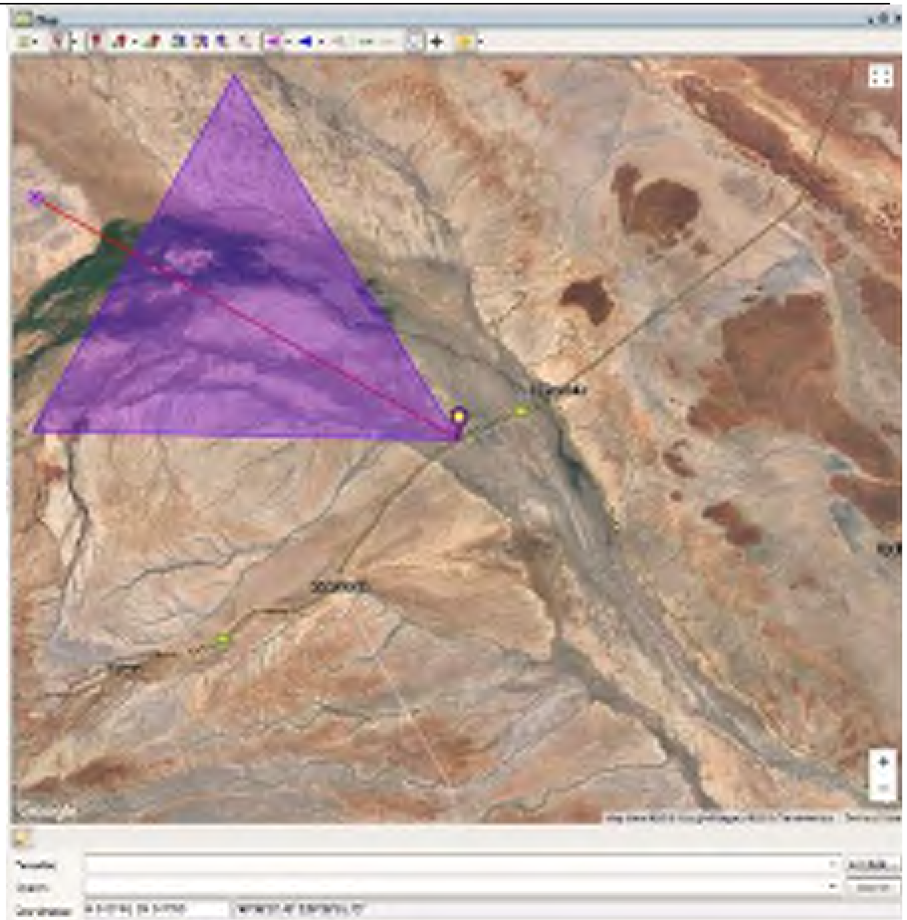
Description: Backward view of approach to a box culvert location.
Coordinates: N0°56'37.77" E39°20'52.13"
Altitude: 216.8m

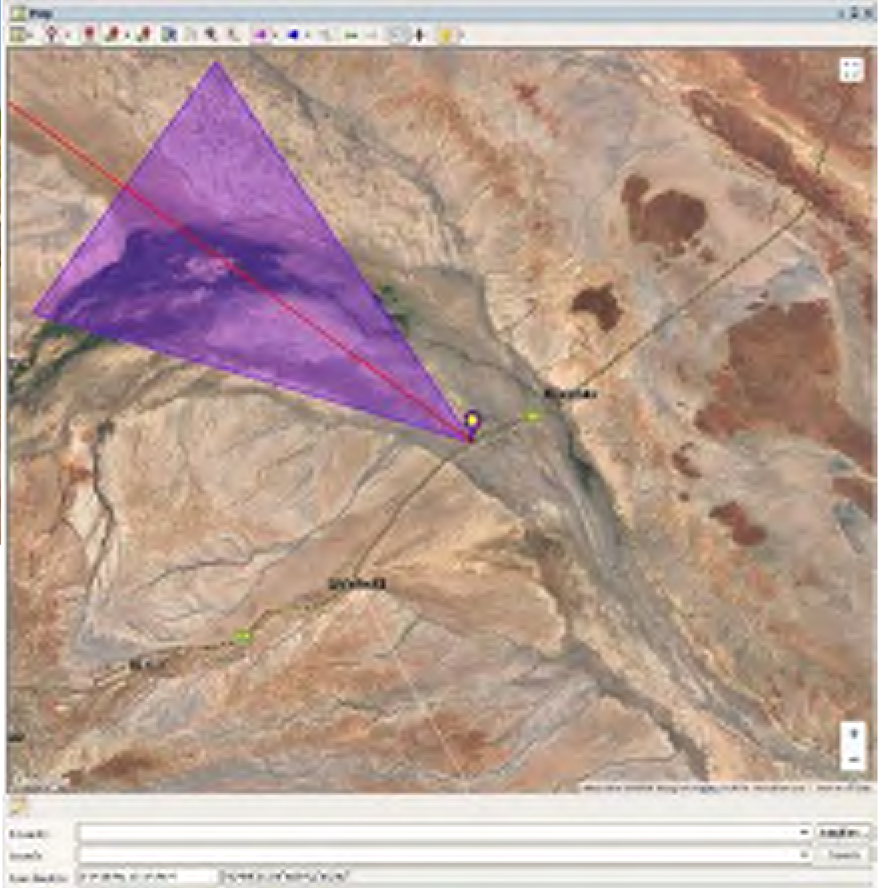
Point 28



Description: Upstream view on the lhs of a box culvert crossing.
Coordinates: N0°56'37.48" E39°20'51.73"
Altitude: 217.0m

Point 28



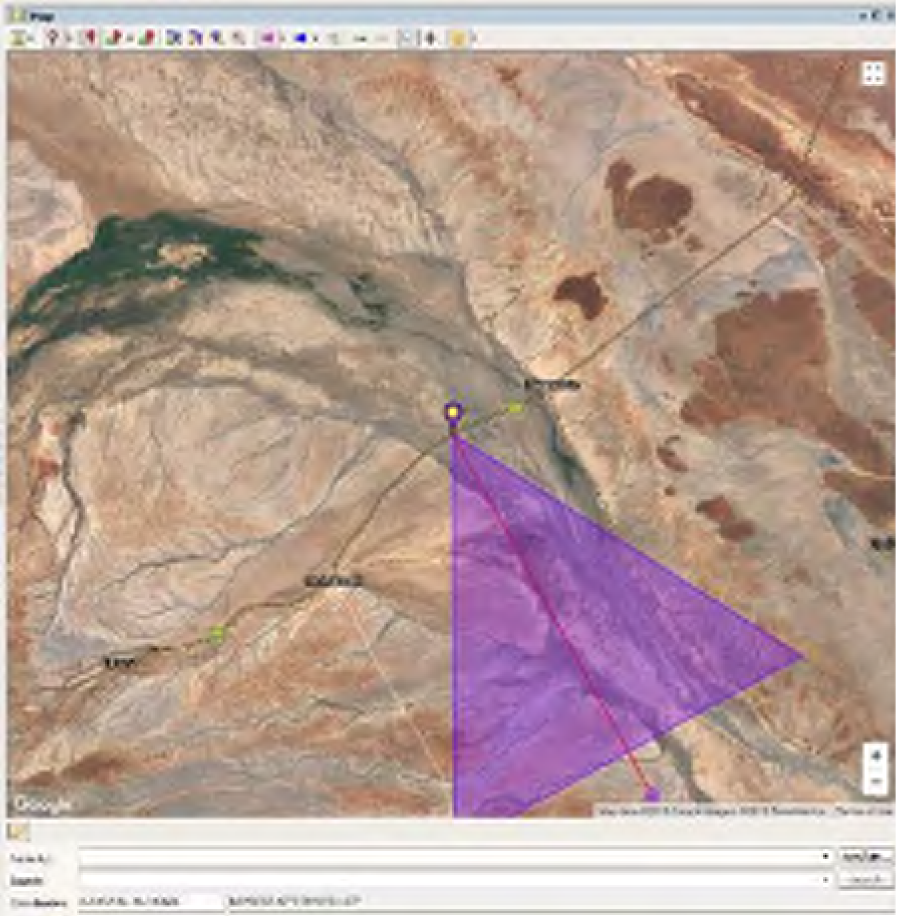


Description: Inlet view of the 5m by 2m twin box culvert on the lhs, with water stagnant at the drainage structure.
Coordinates: N0°56'37.95" E39°20'51.63"
Altitude: 175.0m

Point 28

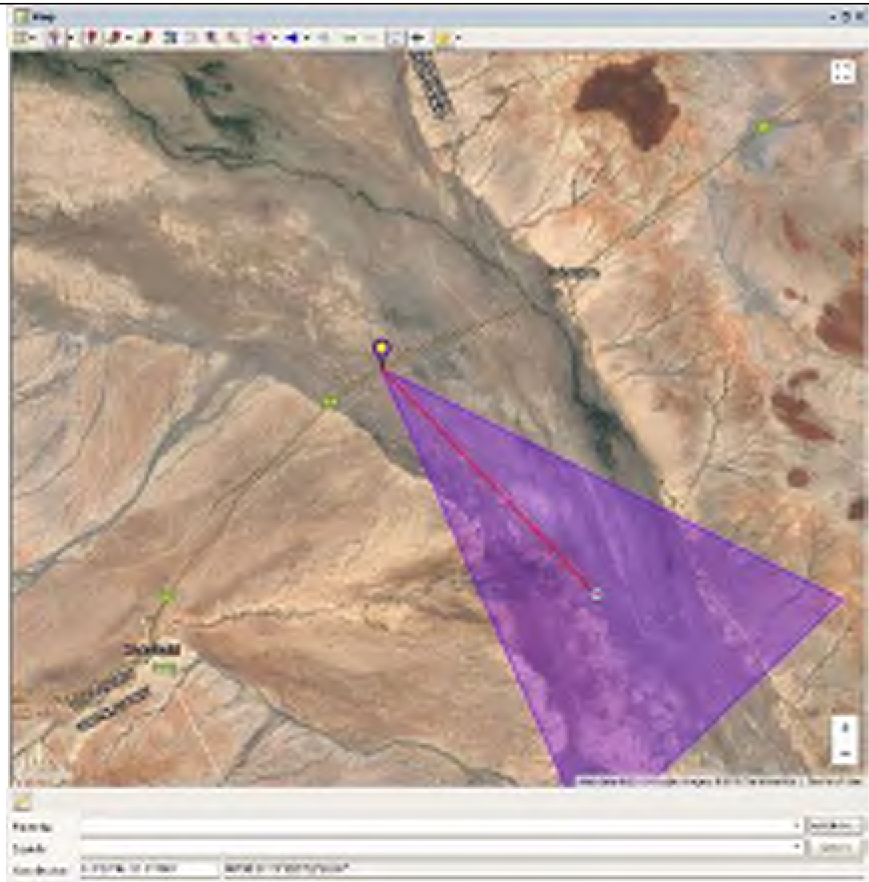
Description: Downstream view on the rhs of a box culvert crossing.
Coordinates: N0°56'37.42" E39°20'51.67"
Altitude: 216.3m

Point 29



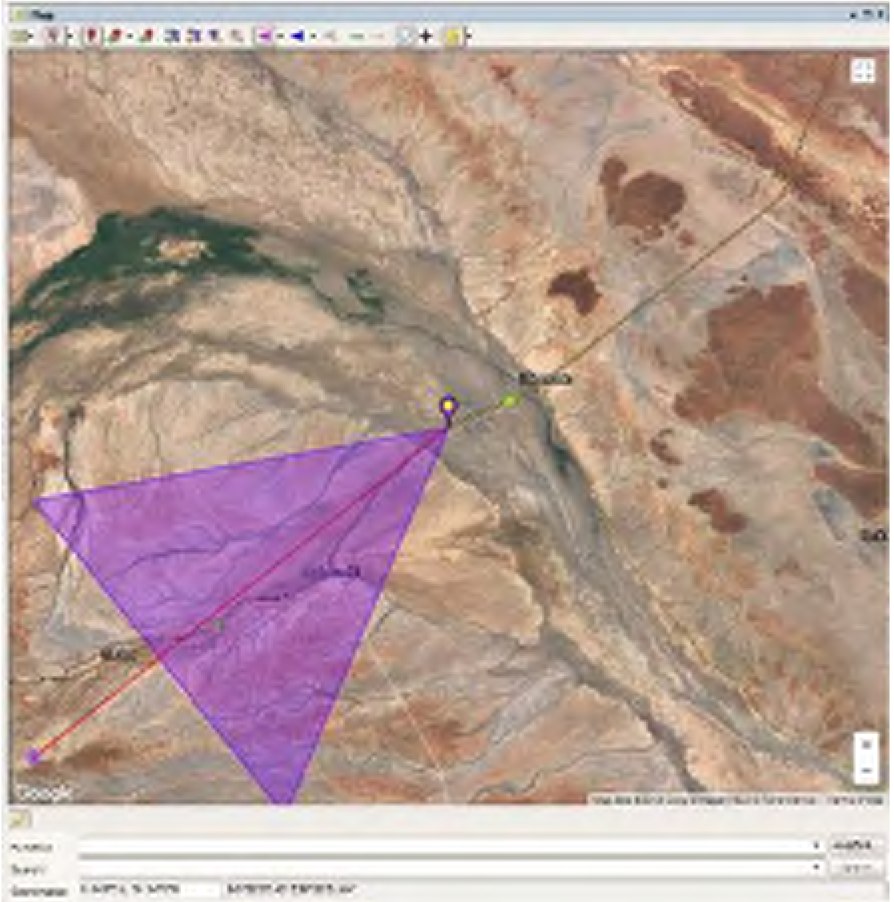
Description: Outlet view of the 5m by 2m twin box culvert on the rhs.
Coordinates: N0°56'37.49" E39°20'51.67"
Altitude: 198.0m

Point 28



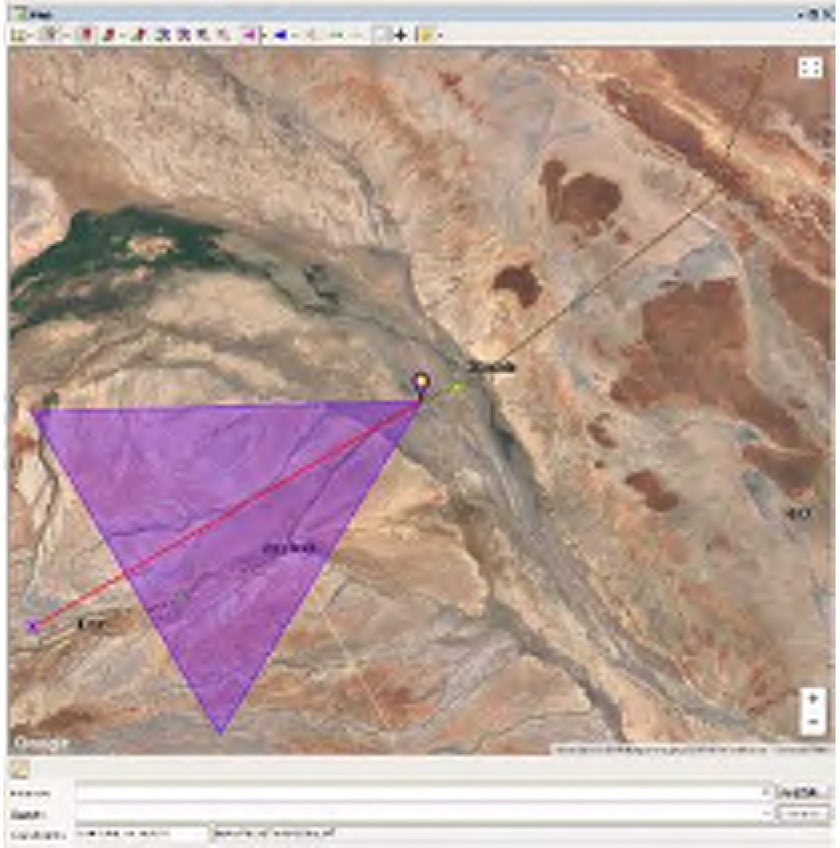
Description: Backward view of the approach to the box culvert crossing.
Coordinates: N0°56'37.43" E39°20'51.64"
Altitude: 216.3m

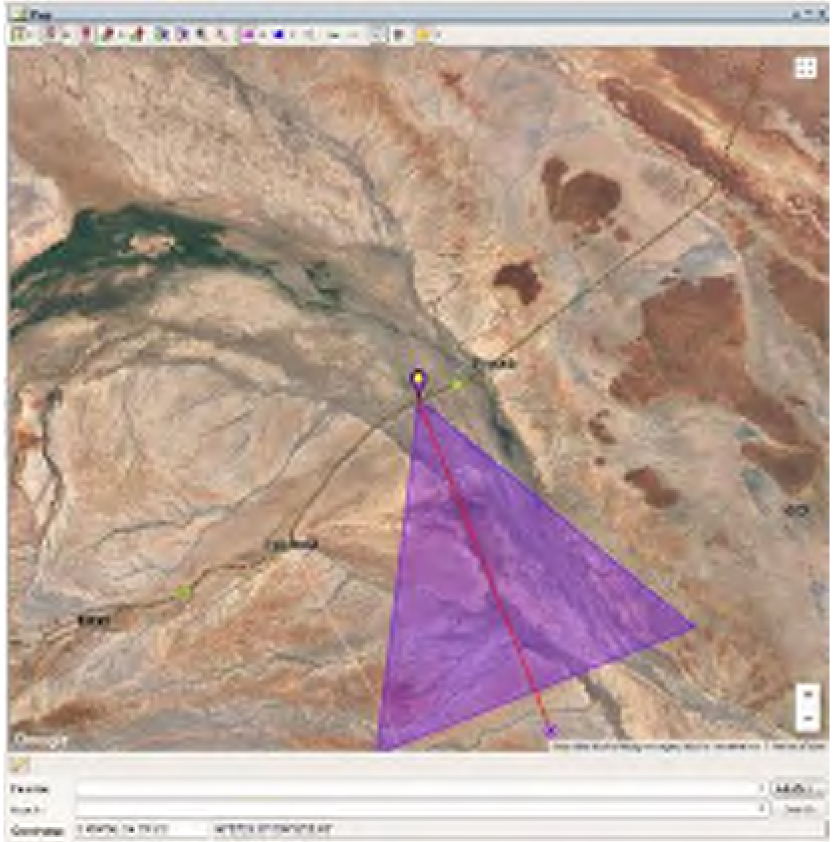
Point 28



Description: Backward view of the flood plain on the sides of the gravel road.
Coordinates: N0°57'42.30" E39°22'55.24"
Altitude: 203.2m

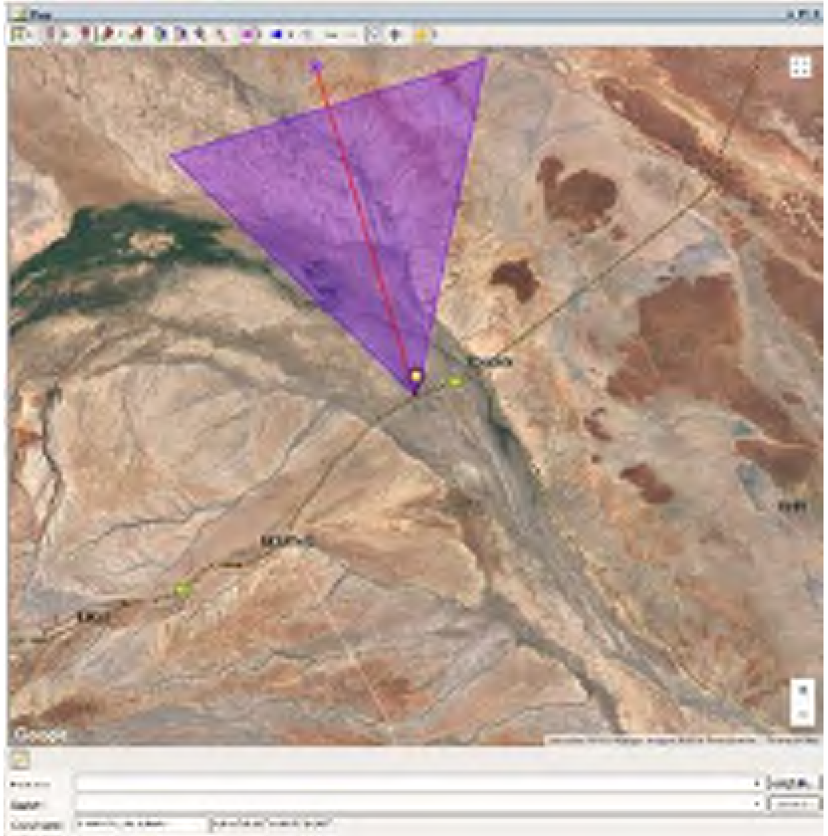
Point 29



 Description: Rhs view of the flooded plain at the Lorian Swamp. Coordinates: N0°57'35.05" E39°22'35.95" Altitude: 213.4m Point 29	

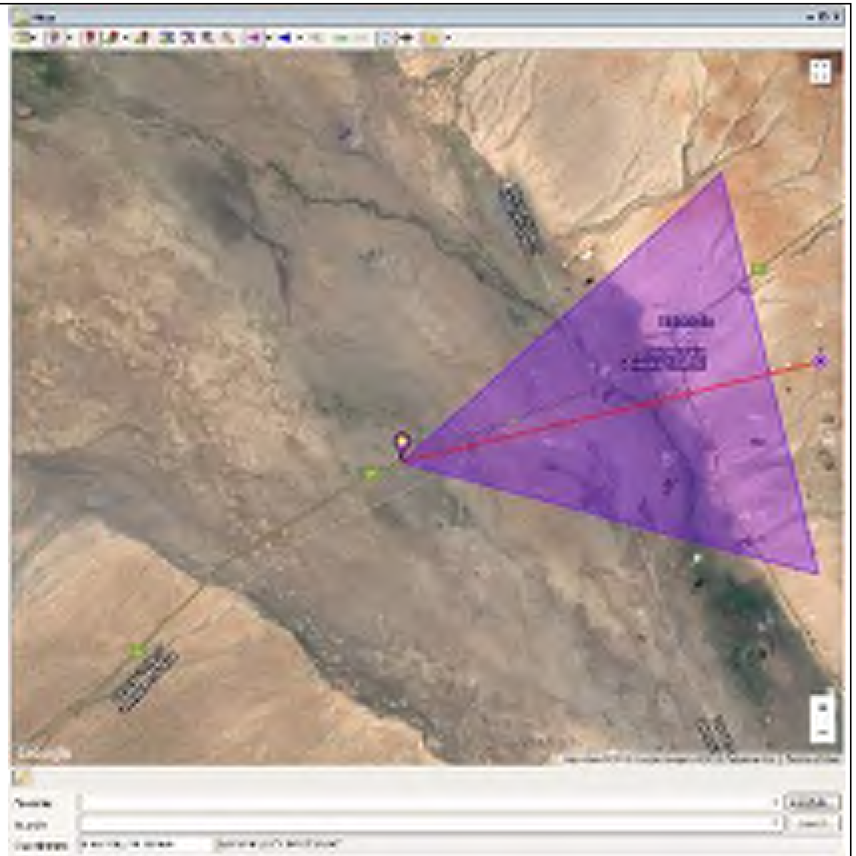
Description: Lhs view of the flooded plain at the Lorian Swamp.
Coordinates: N0°57'35.00" E39°22'35.93"
Altitude: 215.2m

Point 29



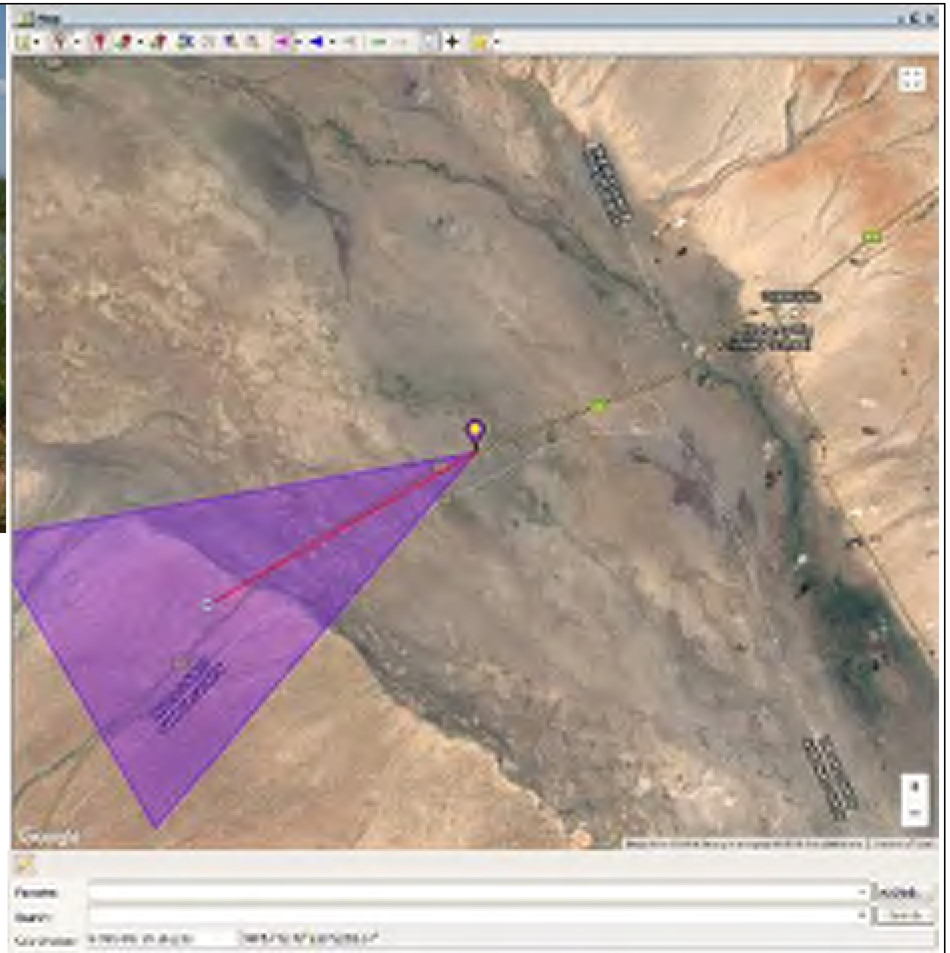
Description: Forward view of the flooded plain at the Lorian Swamp with overgrown thorny shrubs.
Coordinates: N0°57'42.25" E39°22'55.09"
Altitude: 215.2m

Point 29



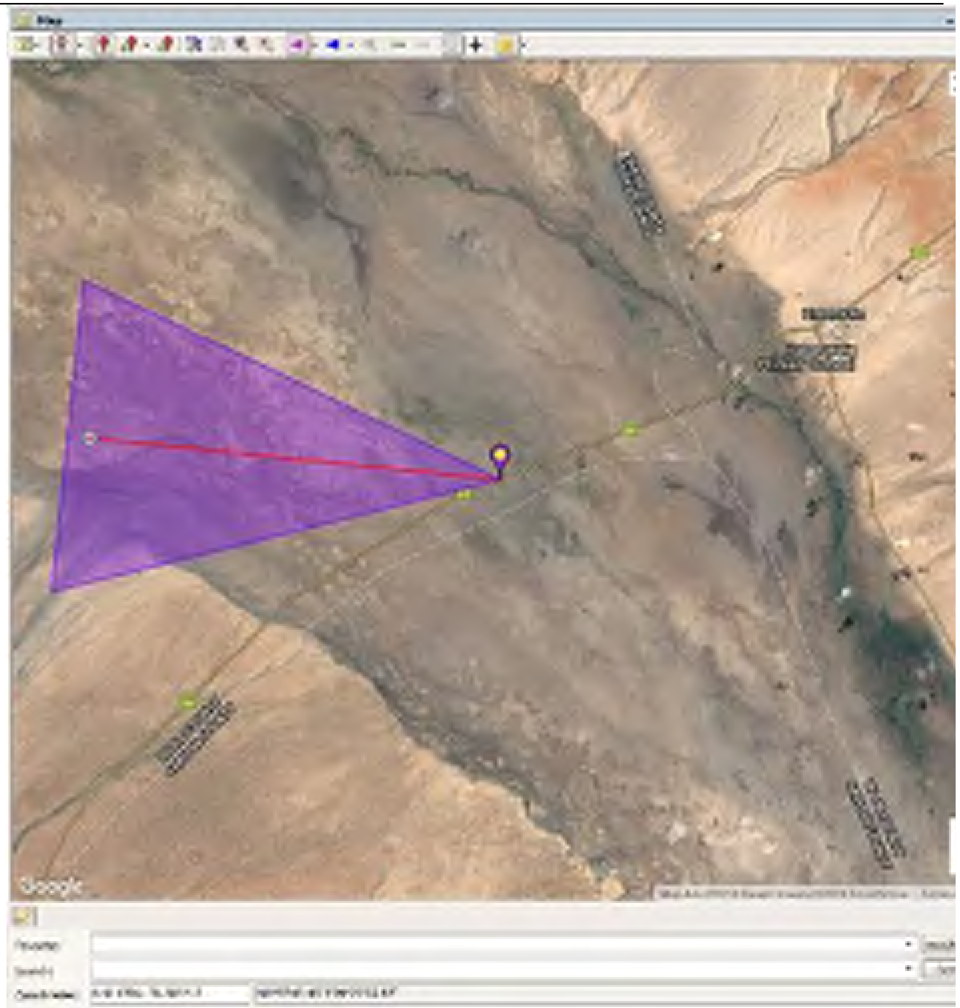
Description: Backward view of the approach to a balancing box culvert at the flooded plain at the Lorian Swamp.
Coordinates: N0°57'42.43" E39°22'55.97"
Altitude: 215.2m

Point 29



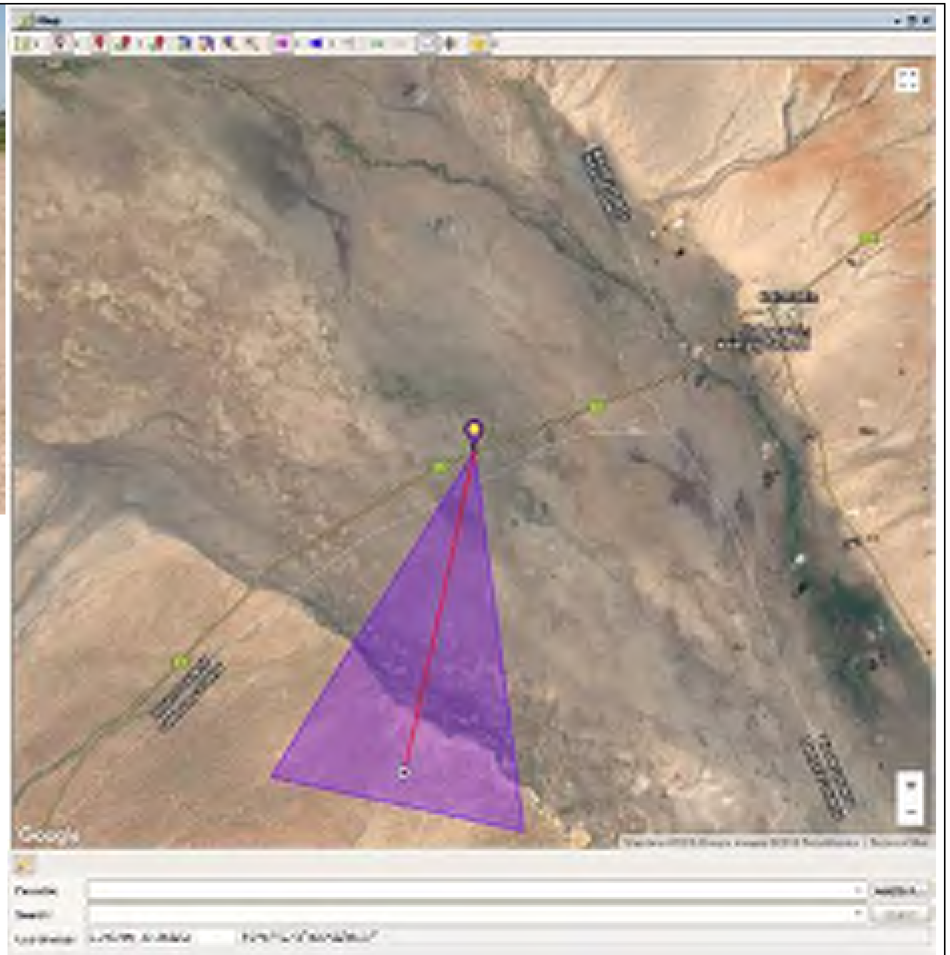
Description: Lhs view of the Lorian Swamp flood plain.
Coordinates: N0°57'42.43" E39°22'55.97"
Altitude: 215.2m

Point 29



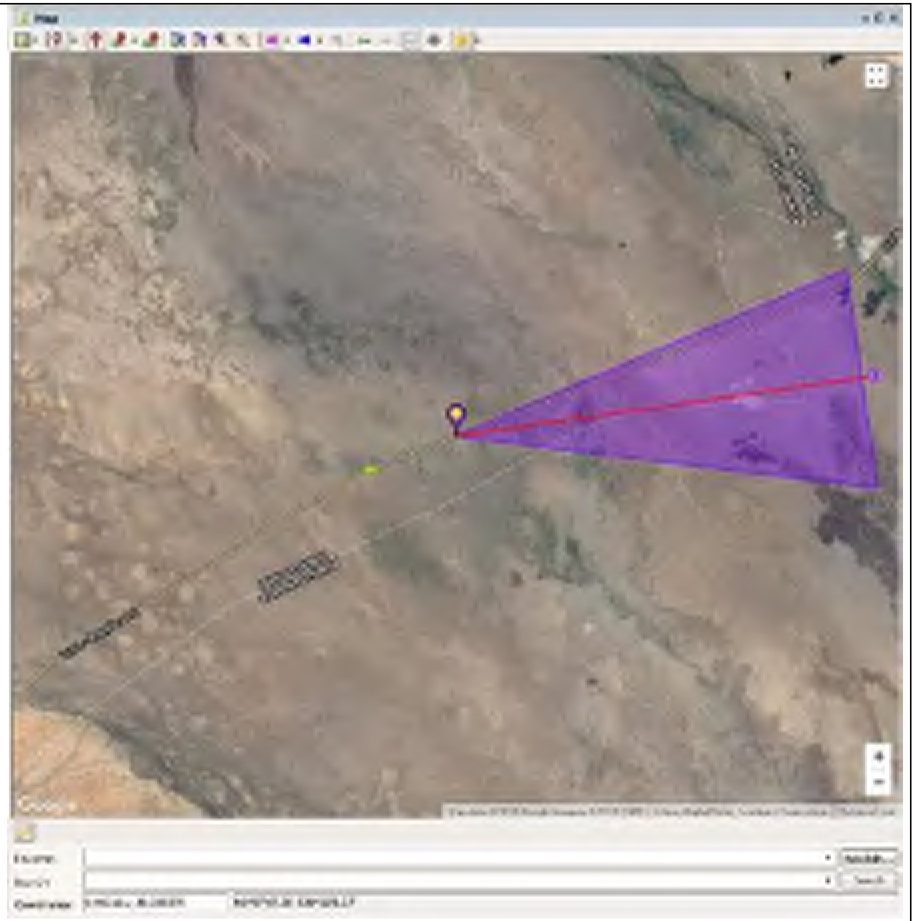
Description: Rhs view of the Lorian Swamp flood plain.
Coordinates: N0°57'42.43" E39°22'55.97"
Altitude: 215.2m

Point 29



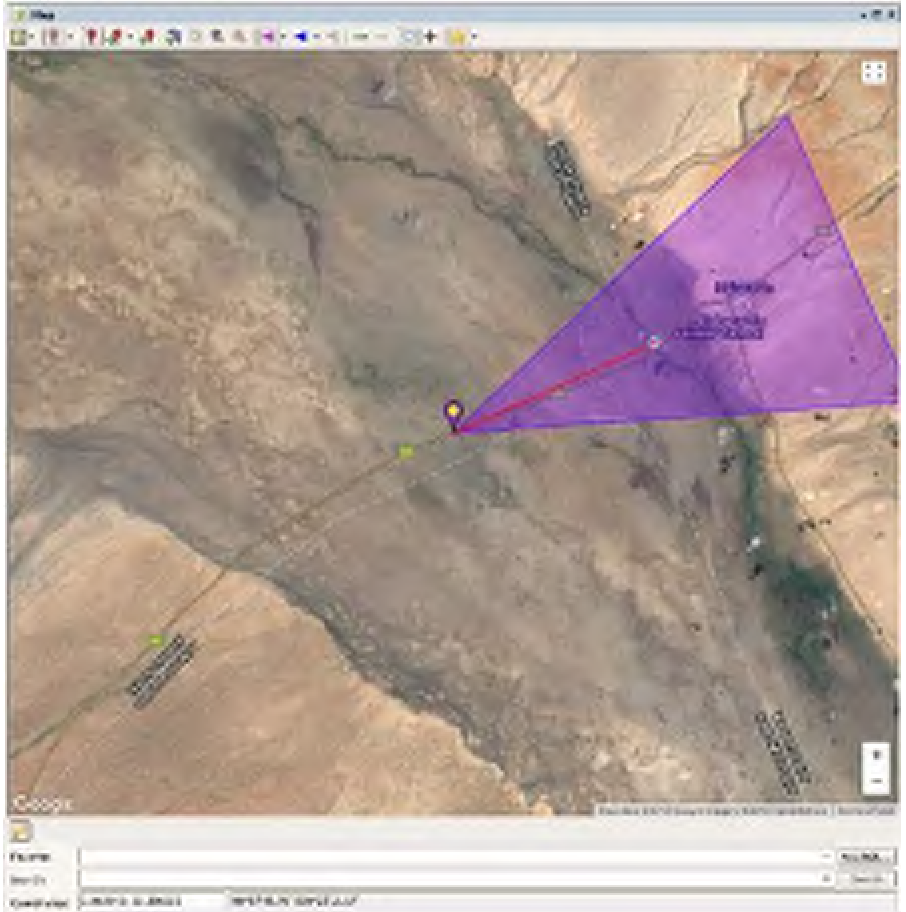
Description: Forward view of a water crossing at the flooded plain with no drainage structure.
Coordinates: N0°57'47.38" E39°23'8.07"
Altitude: 187.3m

Point 30



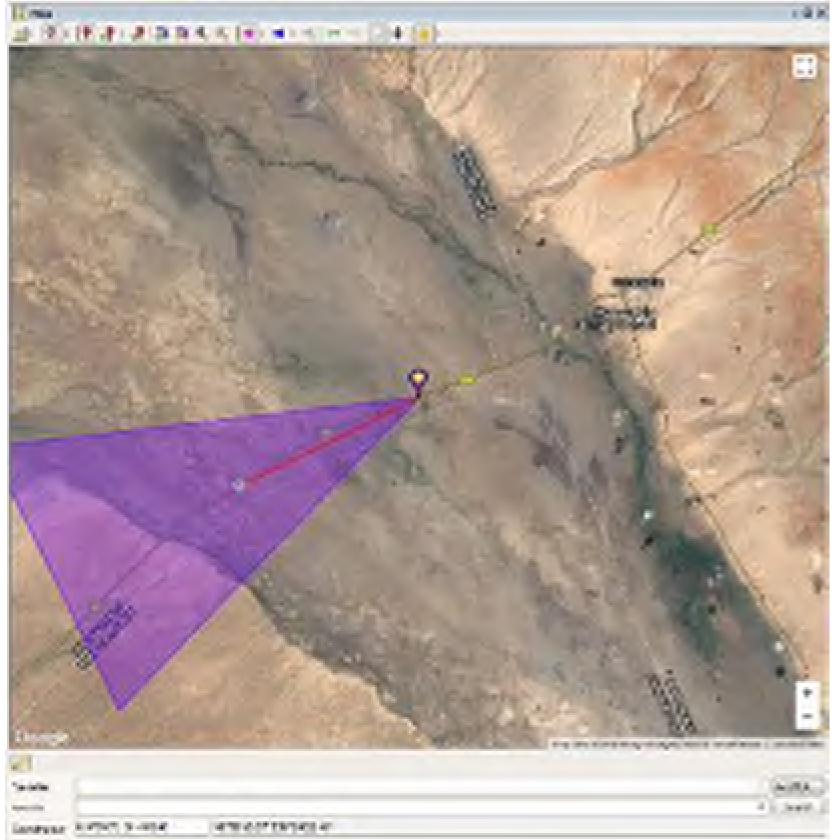
Description: Forward view of a water crossing at a drift on the flooded plain
Coordinates: N0°57'47.38" E39°23'8.07"
Altitude: 189.0m

Point 32



Description: Backward view of the approach to a balancing twin box culvert
Coordinates: N0°58'15.37" E39°24'22.46"
Altitude: 171.0m

Point 33



Description: Side view of the balancing twin box culvert rhs.
Coordinates: N0°58'15.37" E39°24'22.46"
Altitude: 171.0m

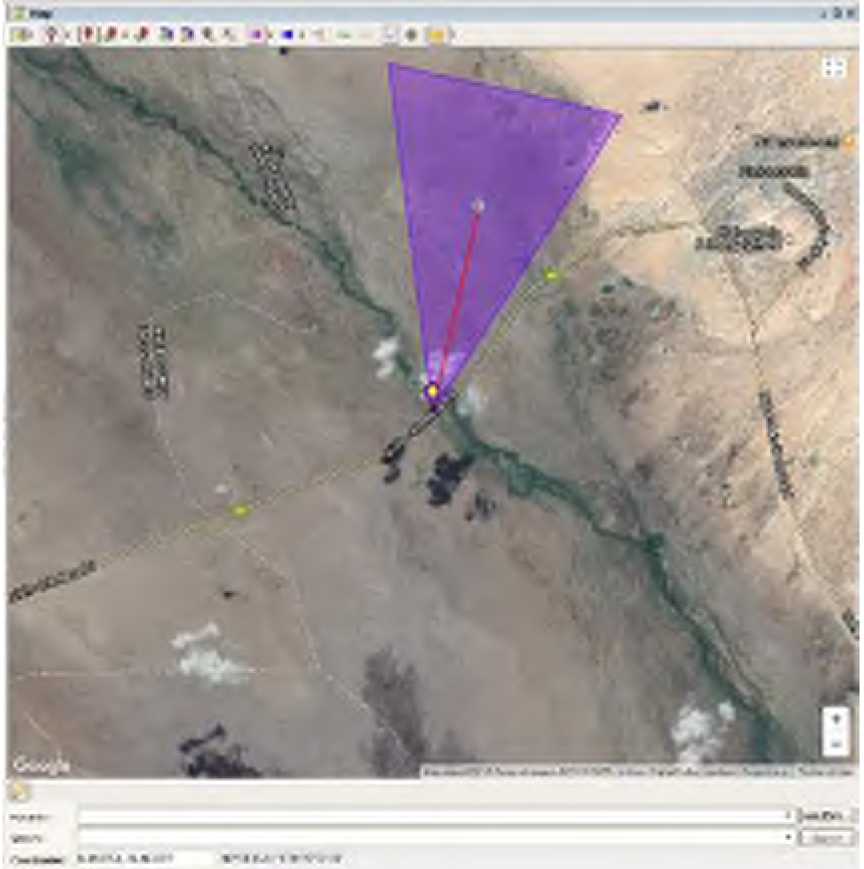
Point 33

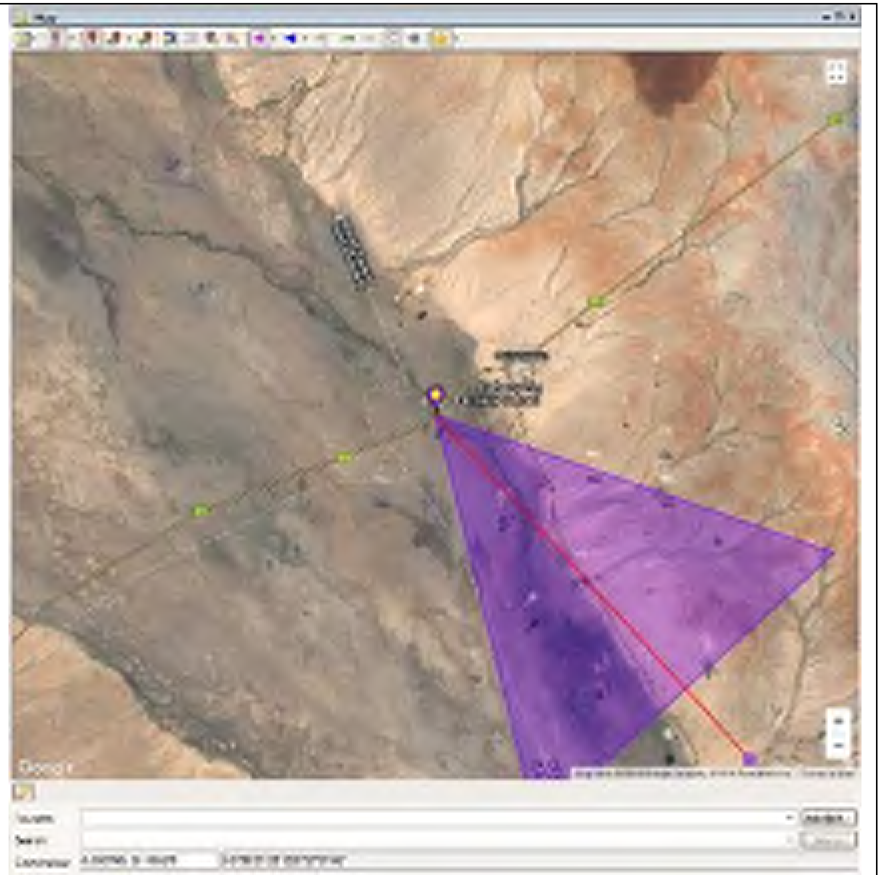
Description: Lhs view of the 1.2m diameter balancing triple culvert.
Coordinates: N0°58'15.37" E39°24'22.46"
Altitude: 171.0m

Point 34

Description: Rhs view of the 1.2m diameter balancing triple culvert.
Coordinates: N0°59'37.51" E39°27'37.18"
Altitude: 171.0m

Point 34



 Description: Rhs view of the 1.2m diameter balancing triple culvert. Coordinates: N0°59'37.35" E39°27'37.00" Altitude: 171.0m Point 34	

Description: Backward view of a 6m composite bridge.
Coordinates: N0°59'44.35" E39°27'43.98"
Altitude: 189.0m

Point 35

Description: Backward view of a 6m composite bridge.
Coordinates: N0°59'44.28" E39°27'43.93"
Altitude: 189.0m

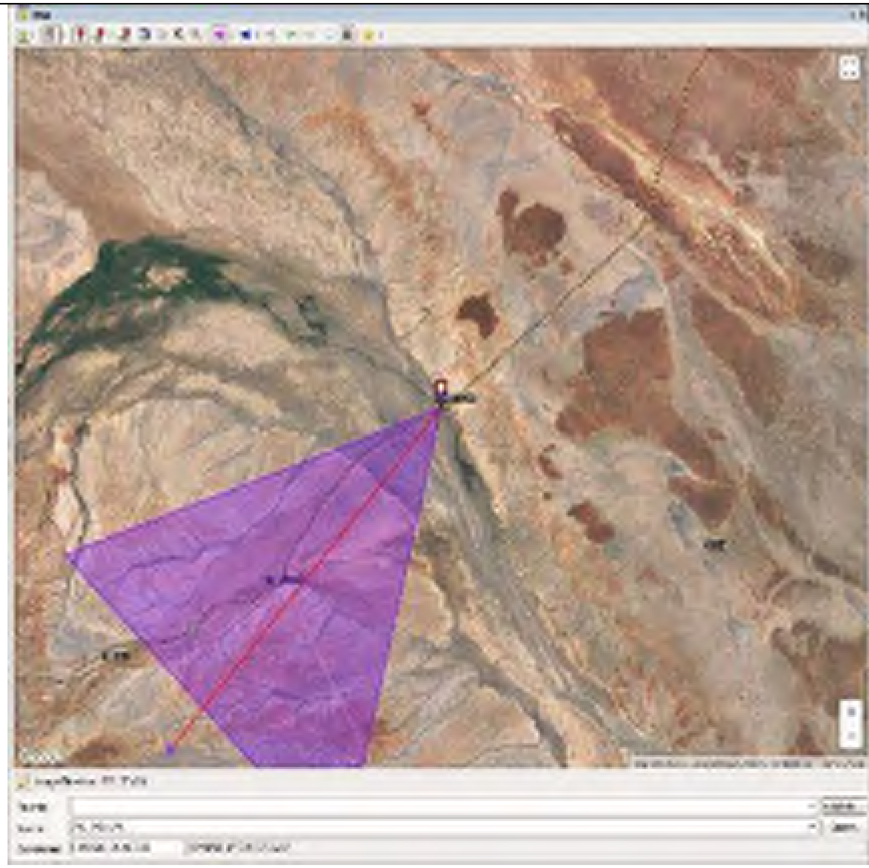
Point 35

Description: Section of the gravel road, undermined by the flooding waters.
Coordinates: N0°57'48.76" E39°23'13.17"
Altitude: 187.3m

Point 36

Description: Drift crossing location, with water scouring on the sides of the drift.
Coordinates: N0°59'58.91" E39°27'56.87"
Altitude: 205.6 m

Point 37

 Description: Forward view of the First Washed out drift, preventing passage of vehicles from Isiolo to Habaswein Coordinates: N0°59'58.87" E39°27'56.88" Altitude: 205.6 m Point 38	

Description: Forward view of the second Washed out drift location, with a lot of water on both sides of the road, hence no diversions for vehicles to pass.
Coordinates: N0°59'45.76" E39°27'45.93"
Altitude: 187.0 m

Point 39

Description: Inspecting vehicles from Isiolo unable to pass towards Habaswein.

Description: People crossing through the water at the washed out drift section.

Description: Flooded water on the rhs of the washed out drift
Coordinates: N0°59'45.56" E39°27'45.54"
Altitude: 187.0 m

Point 39

Description: Flooded water on the lhs of the washed out drift.
Coordinates: N0°59'45.76" E39°27'45.93"
Altitude: 187.0 m

Point 39

Description: Forward view of the third washed out drift location.
Coordinates: N0°59'58.92" E39°27'57.04"
Altitude: 193.0 m

Point 40

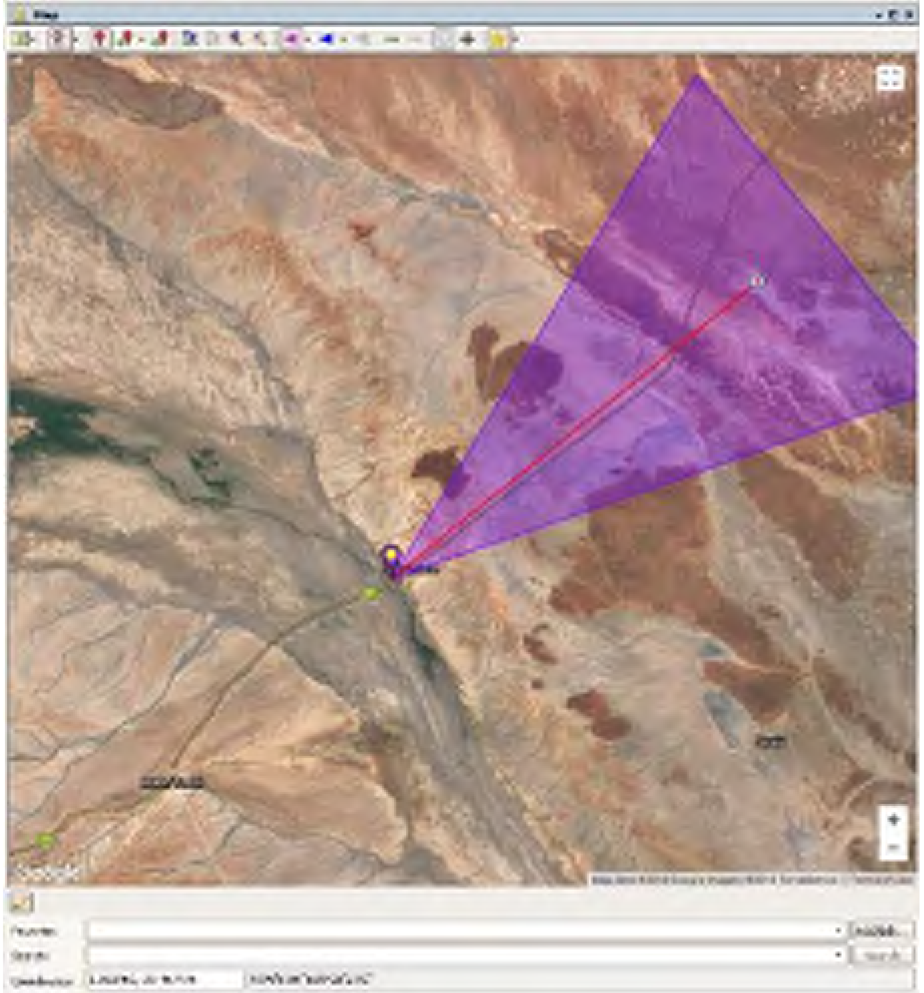
Description: Diversion on the lhs of the third washed out drift.
Coordinates: N0°59'58.92" E39°27'57.04"
Altitude: 193.0 m

Point 40

The three drift locations were the worst affected by the rains, since no vehicle could pass at the second washed out drift. The bottleneck forced all vehicles from Isiolo going to Wajir to pass through Garissa, which is more than 200km from Habaswein. During the site visit, all the vehicles from Isiolo had to turn back at this point, and a different set of vehicles requested from Wajir. The staff had to then pass through the waters in order to proceed with the site visit.

Description: Forward view of the fourth drift location at Habaswein that was almost washed out by the storm water.
Coordinates: N0°59'58.92" E39°27'57.04"
Altitude: 193.0

Point 41

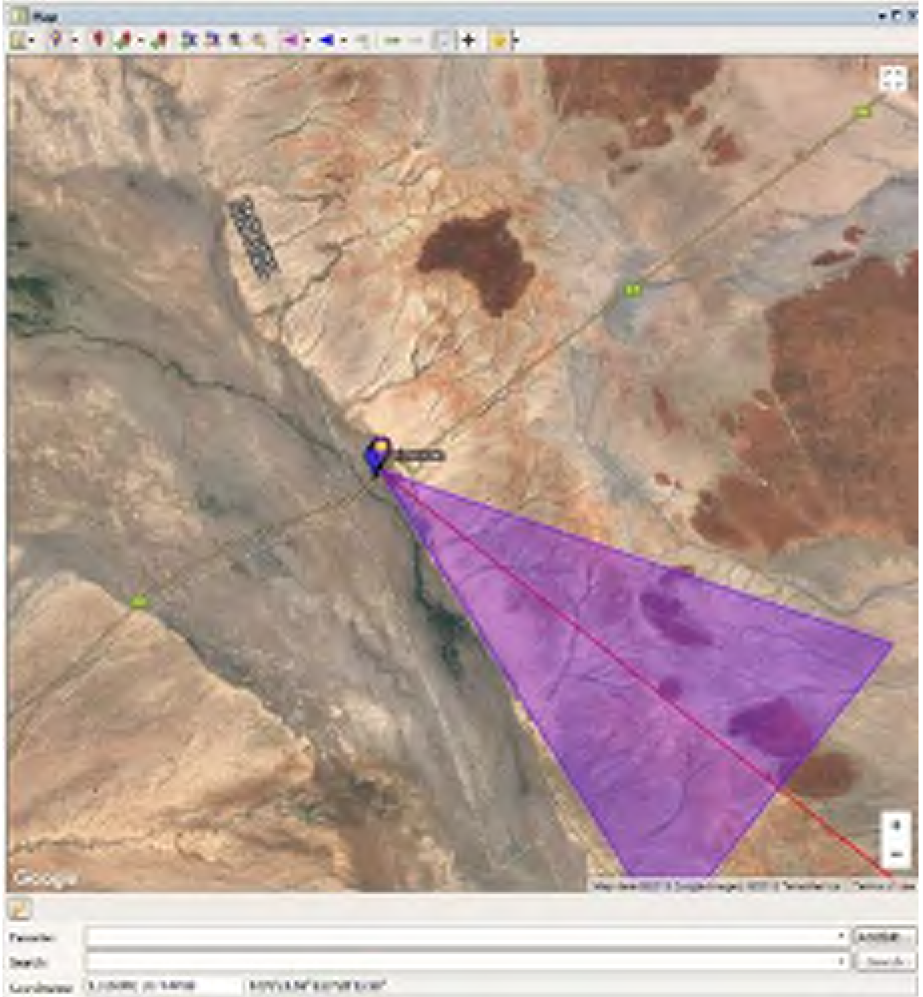


Description: Forward view to the Location of a 900mm diameter twin pipe culvert destroyed by the rain water.
Coordinates: N1°0'21.56" E39°28'13.58"
Altitude: 174.0 m

Point 42

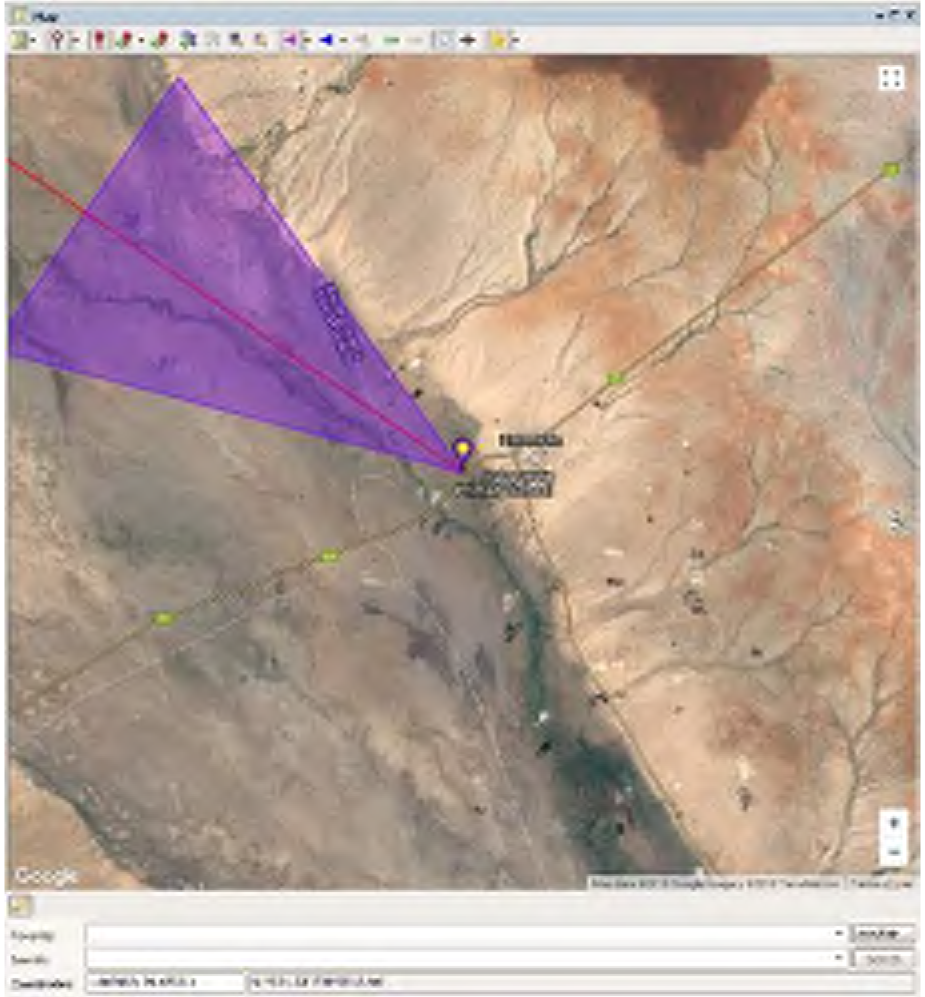
Description: Twin pipe culverts destroyed by the rain water on the lhs
Coordinates: N1°0'21.56" E39°28'13.58"
Altitude: 174.0 m

Point 42



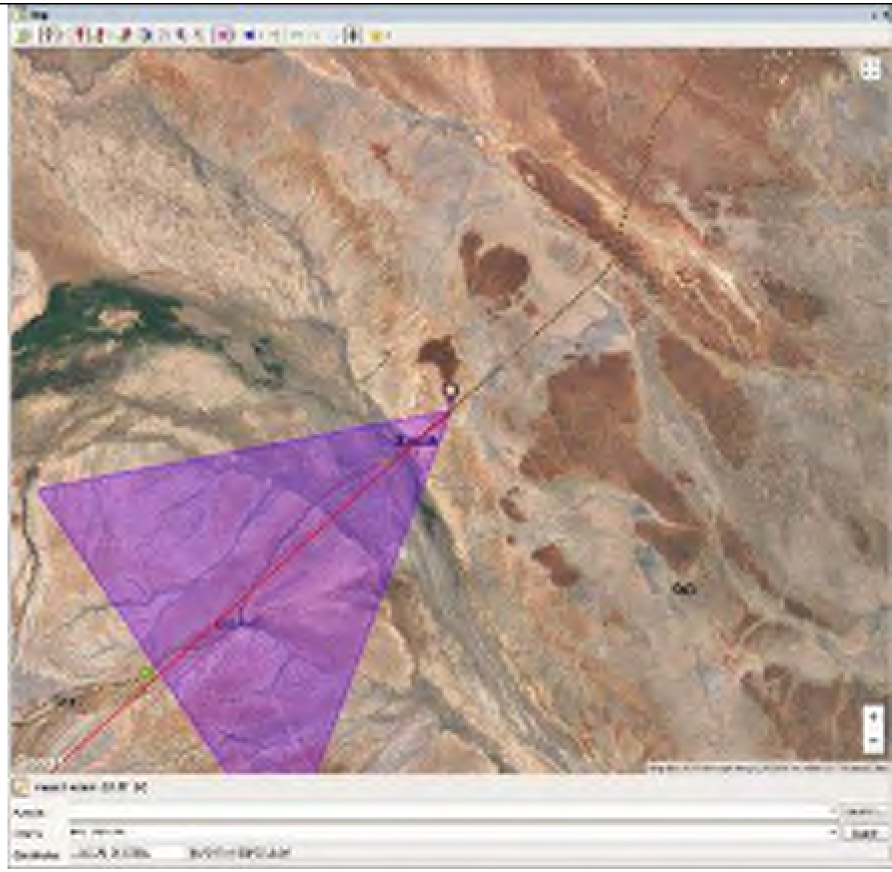
Description: Protection on the twin pipe culvert destroyed by storm water on the lhs.
Coordinates: N1°0'21.53" E39°28'12.94"
Altitude: 174.0 m

Point 42



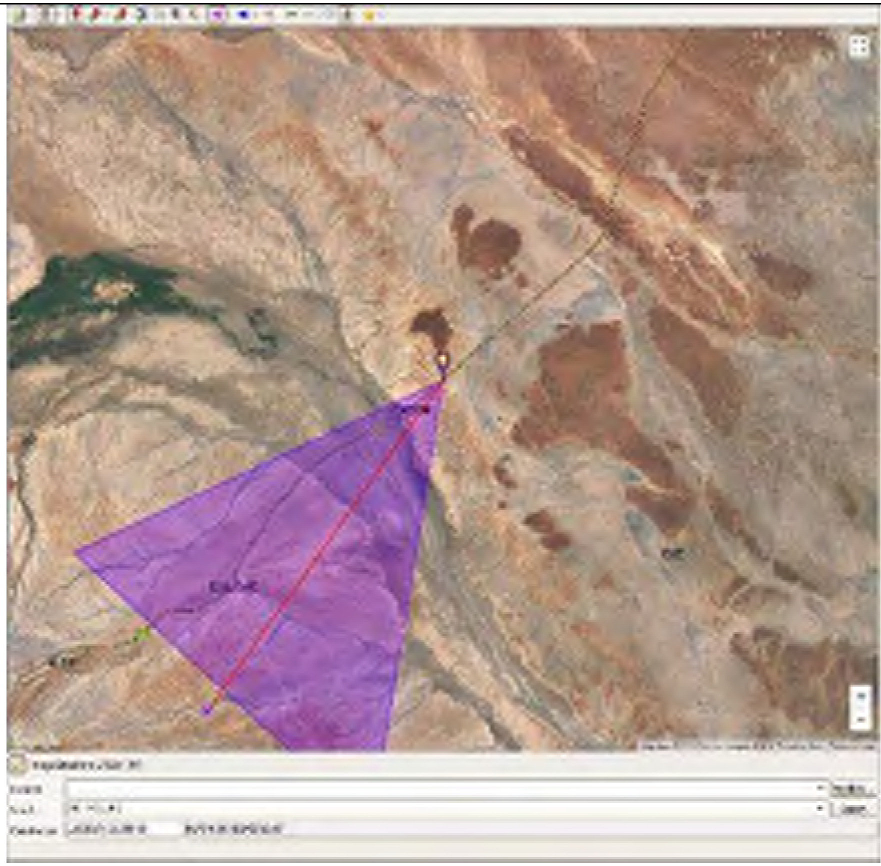
Description: Backward view of a Drift at a water crossing with gabions on the sides.
Coordinates: N1°3'47.44" E39°33'19.84"
Altitude: 258.9 m

Point 43



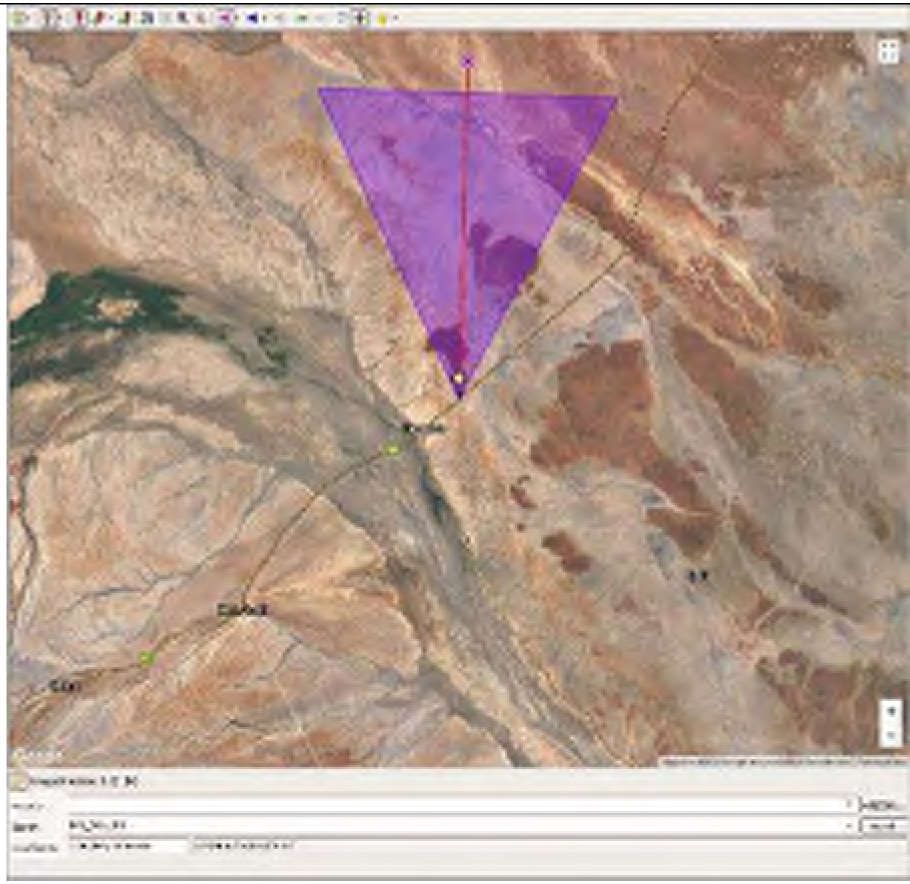
Description: Sandy river bed on the rhs of the drift crossing
Coordinates: N1°3'46.86" E39°33'19.65"
Altitude: 258.9 m

Point 43



Description: Expansion joint at the drift crossing.
Coordinates: N1°3'46.67" E39°33'19.51"
Altitude: 258.9 m

Point 43

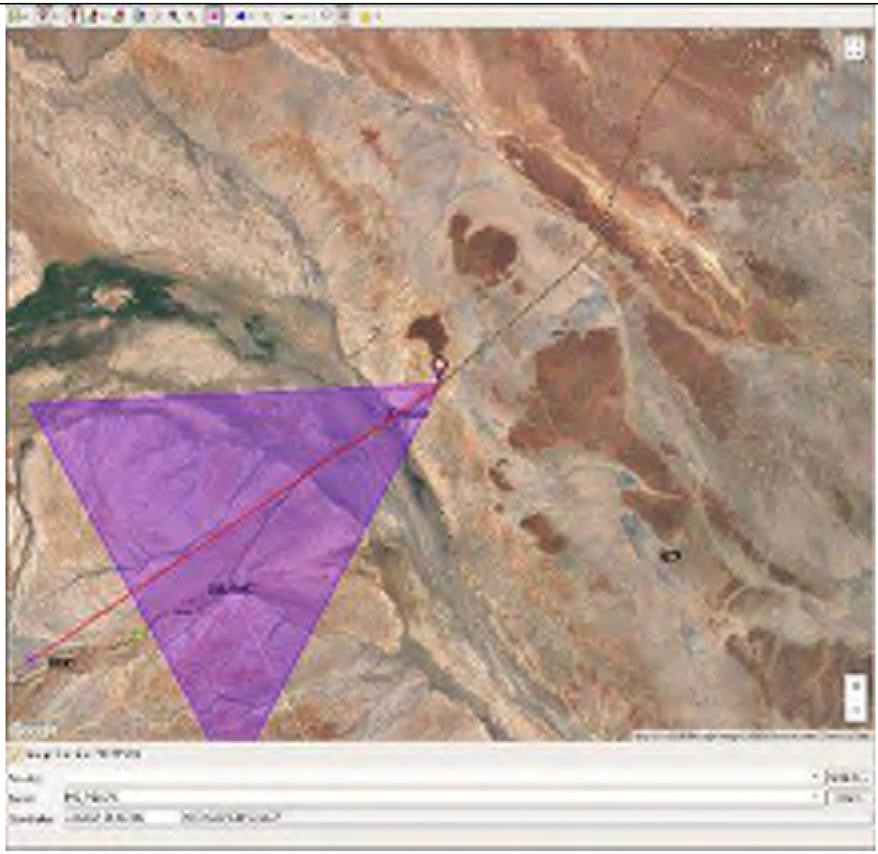


Description: Forward view at the Failed gabions on the sides of the drift.
Coordinates: N1°3'46.67" E39°33'19.51"
Altitude: 258.9 m

Point 43

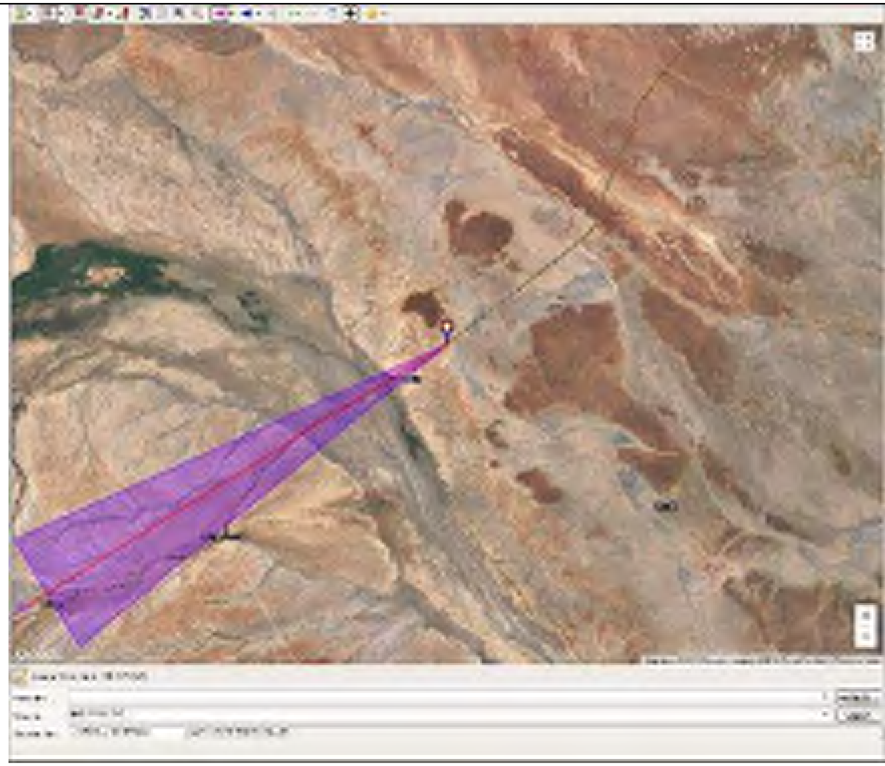
Description: Back ward view of the drift crossing with gabions.
Coordinates: N1°3'46.68" E39°33'19.57"
Altitude: 258.9 m

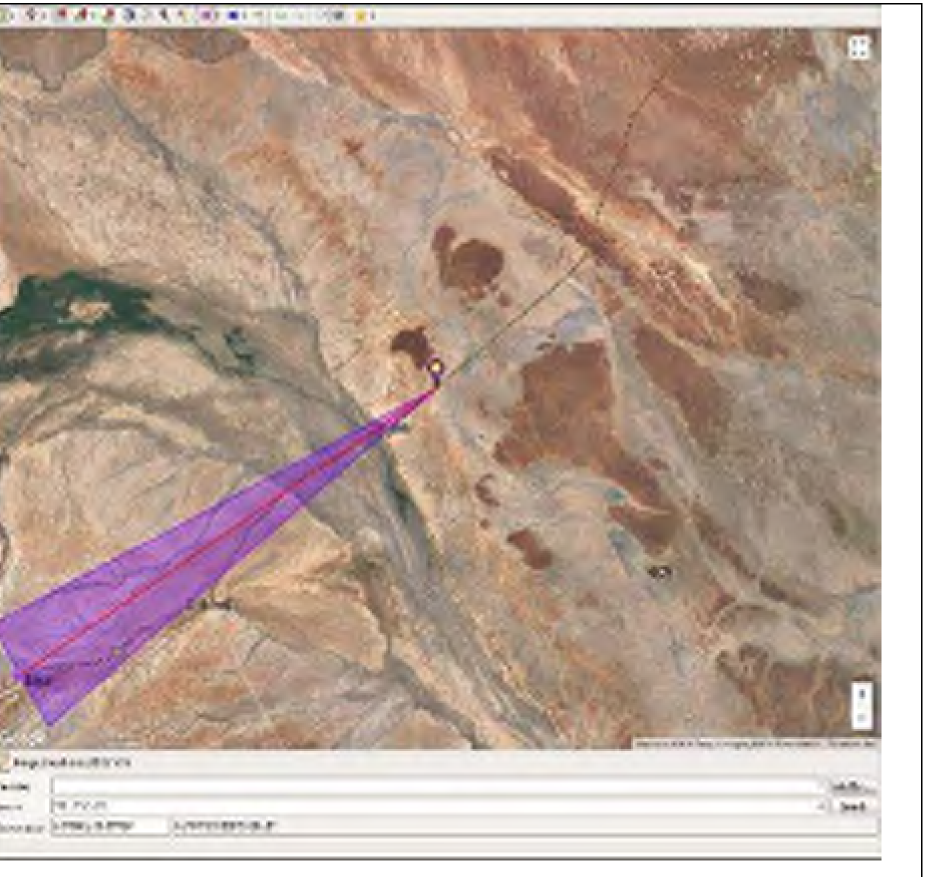
Point 43



Description: Backward view of a sandy road stretch.
Coordinates: N1°4'47.93" E39°34'38.15"
Altitude: 241.3 m

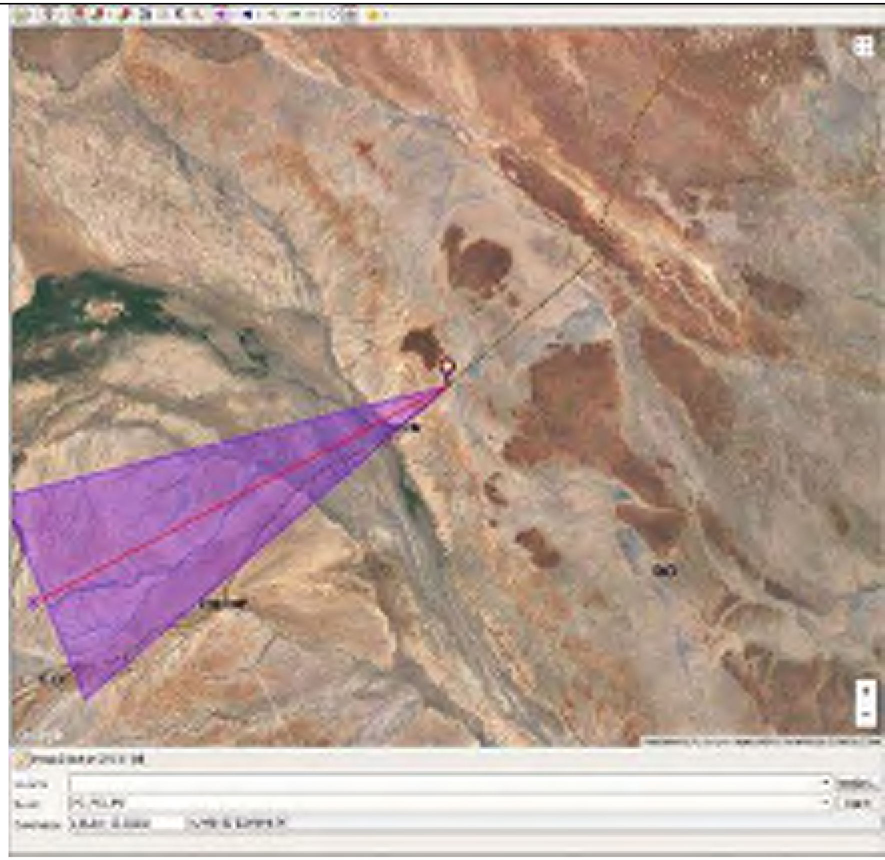
Point 44



 Description: Backward view of the road with loose soils that get the vehicles stuck during the wet season Coordinates: N1°4'47.93" E39°34'38.15" Altitude: 241.3 m Point 44	

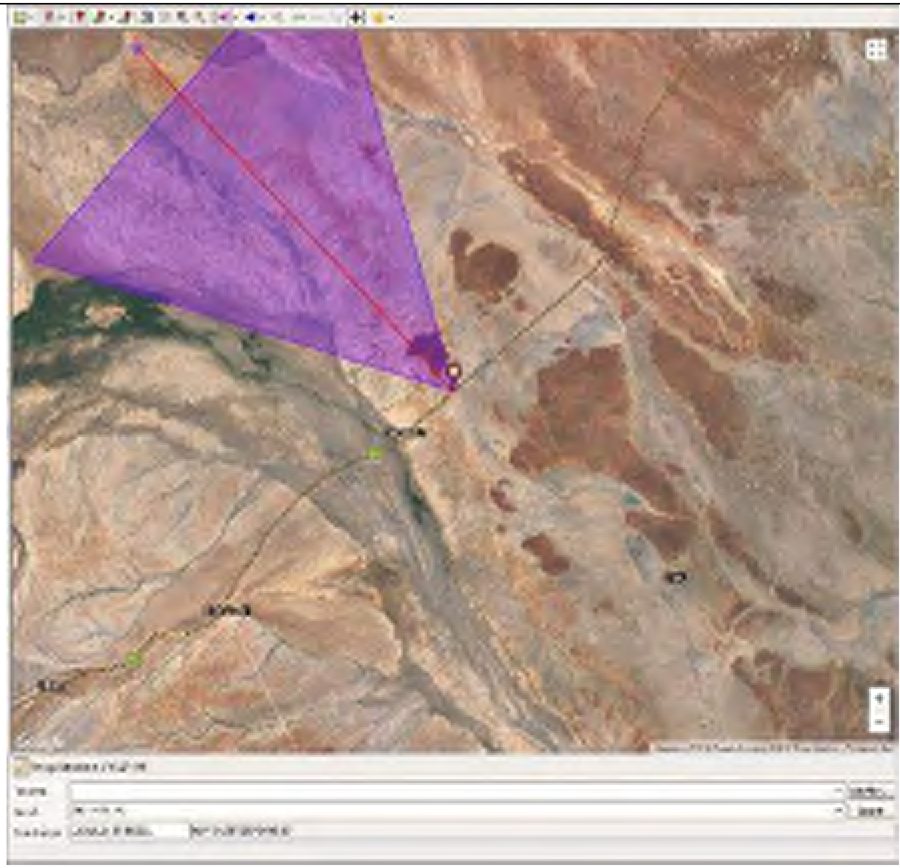
Description: Diversion by vehicles to get away from the sand on the road
Coordinates: N1°4'54.53" E39°34'48.79"
Altitude: 265.6 m

Point 45



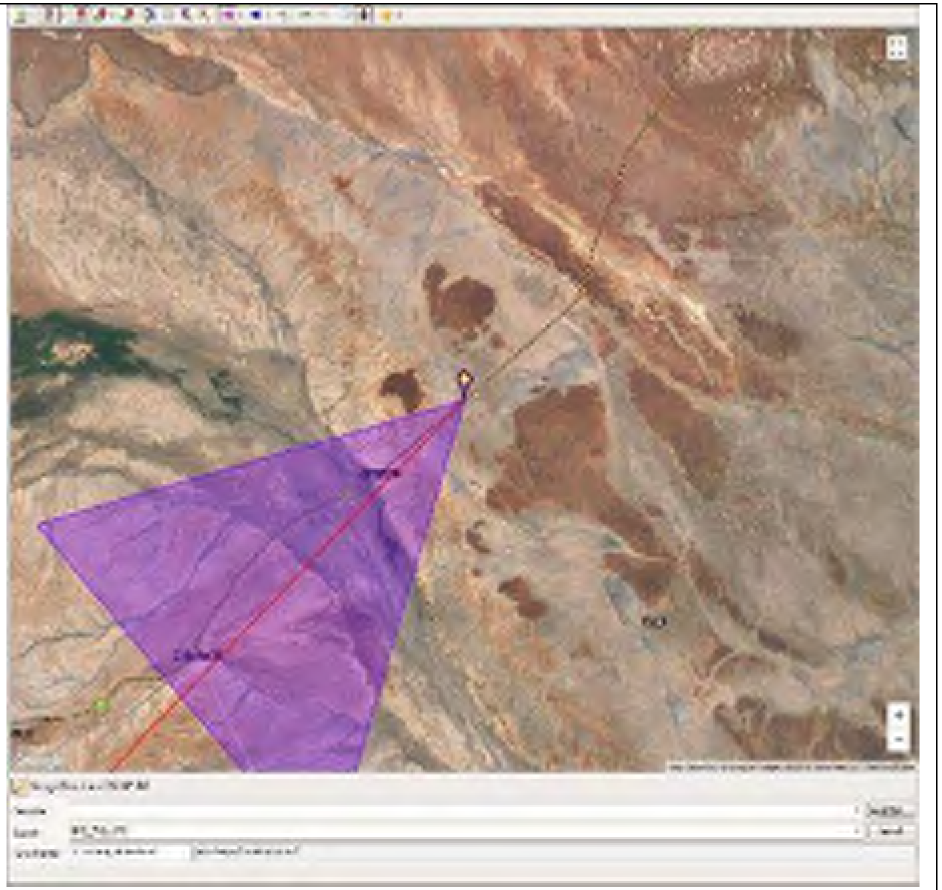
Description: Flat terrain on the lhs of the road.
Coordinates: N1°4'54.55" E39°34'48.83"
Altitude: 260.1 m

Point 45



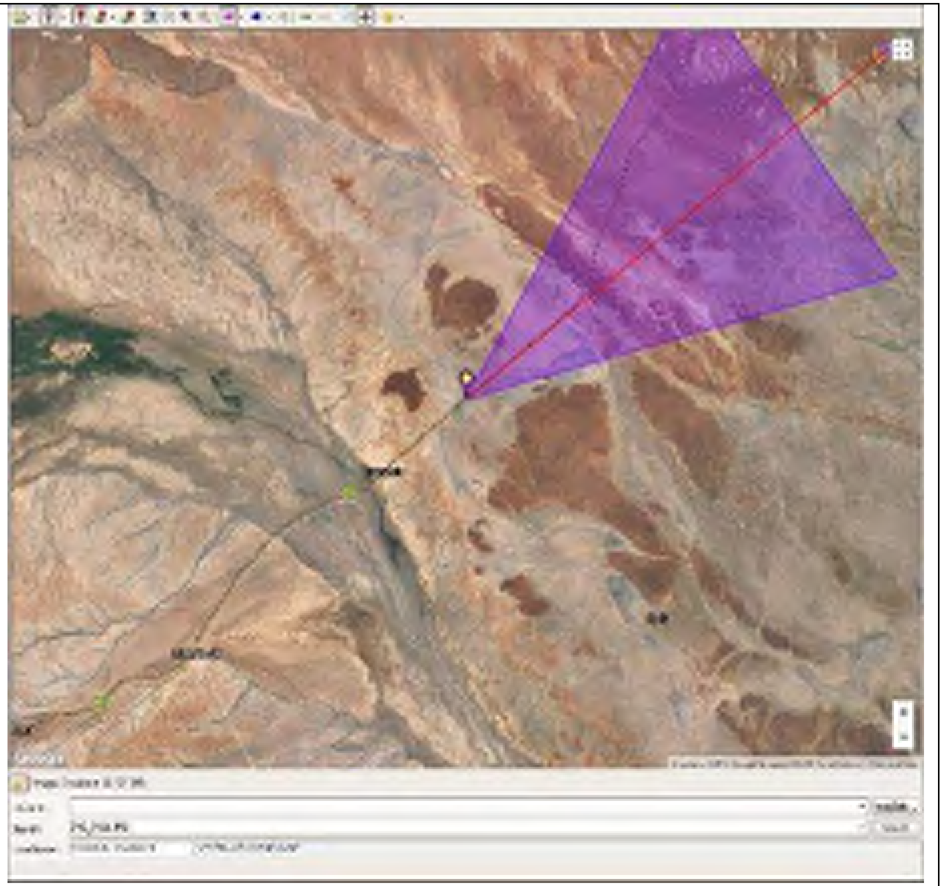
Description: Backward view, showing section of the road with loose soils.
Coordinates: N1°7'48.61" E39°38'33.57"
Altitude: 253.2 m

Point 46.



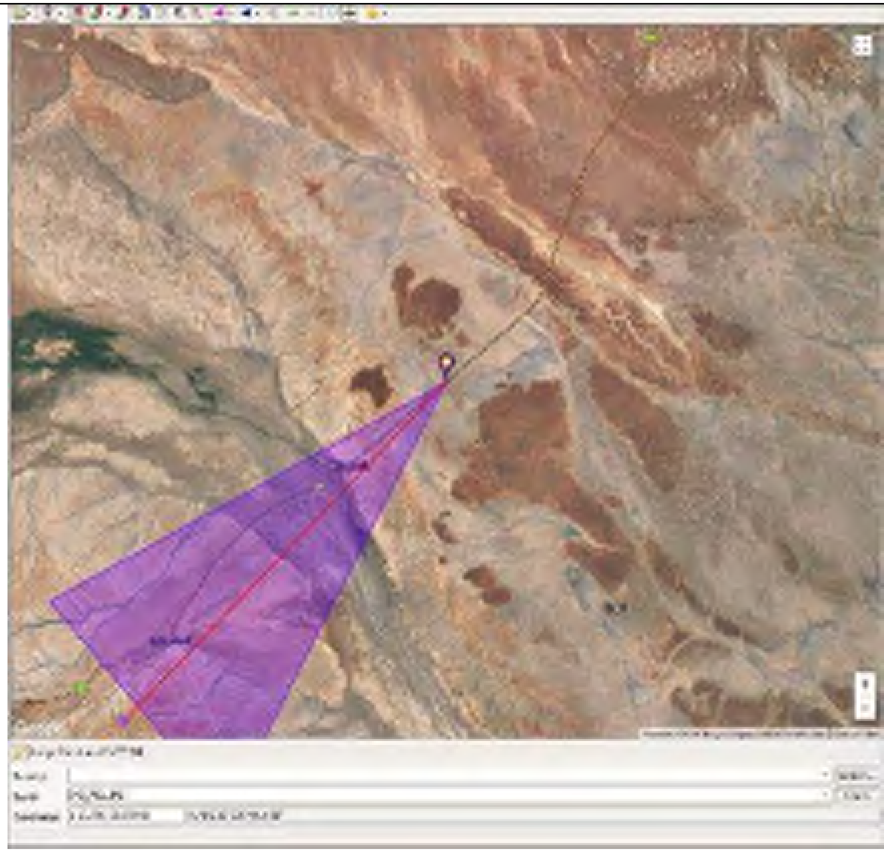
Description: Forward view of the road on the flat terrain.
Coordinates: N1°7'48.50" E39°38'33.40"
Altitude: 251.2 m

Point 46.



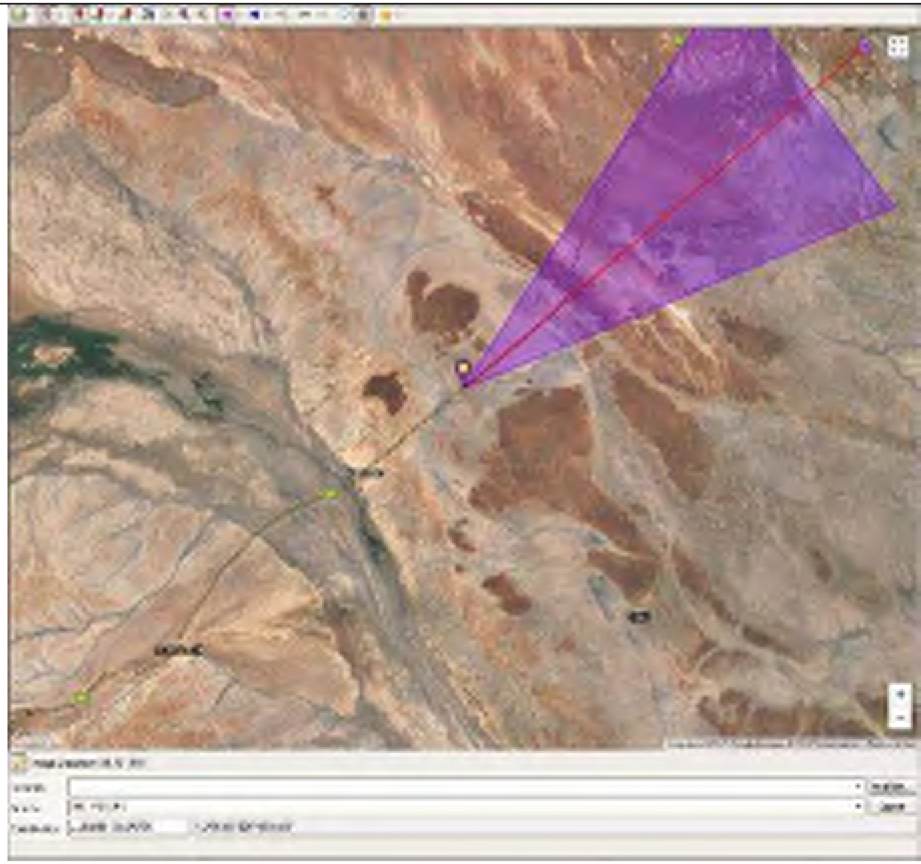
Description: Backward view at the Drift that has been slightly covered by sand.
Coordinates: N1°9'6.26" E39°40'14.59"
Altitude: 251.2 m

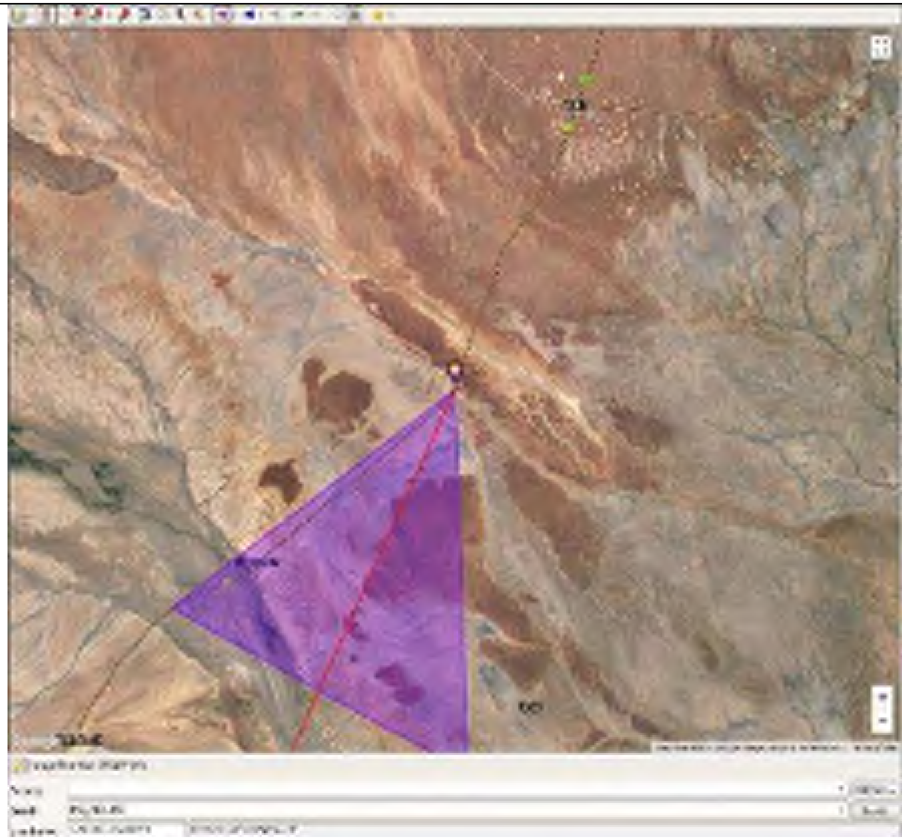
Point 47



Description: Forward view of the Well-maintained murrum road section
Coordinates: N1°9'6.26" E39°40'14.59"
Altitude: 251.6 m

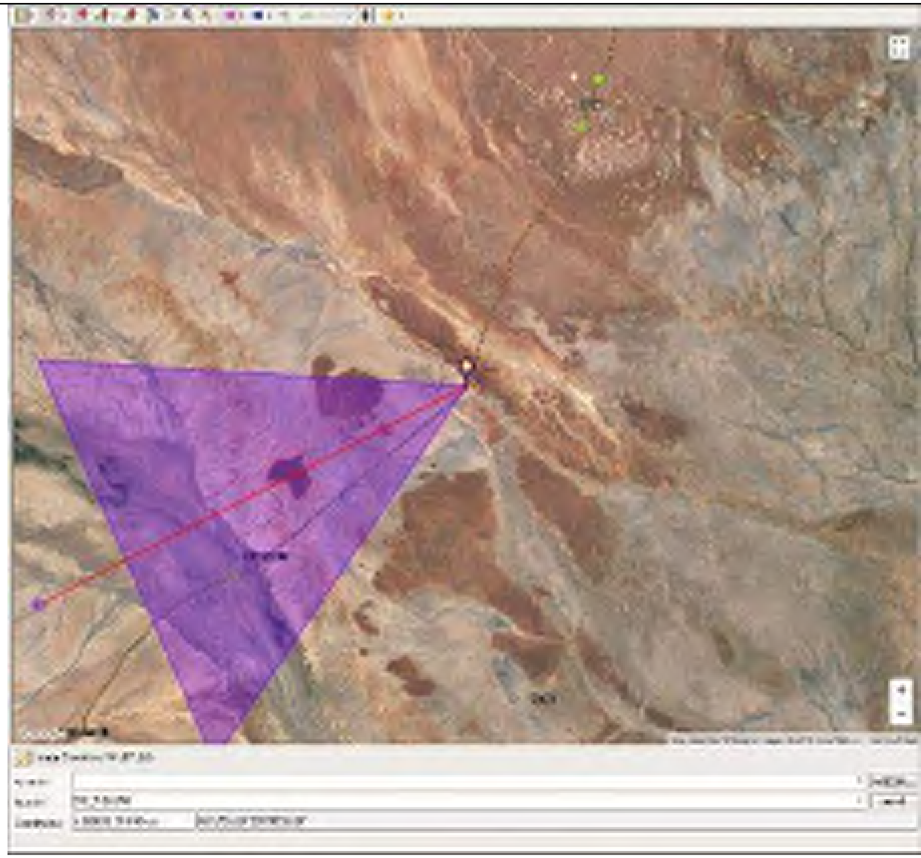
Point 47.



 Description: Drift section (Lagh Boghal) The drift is about 300m long. The submerged section in the rainy season is about 500m long Coordinates: N1°17'31.53" E39°50'36.29" Altitude: 219.4 m Point 48.	

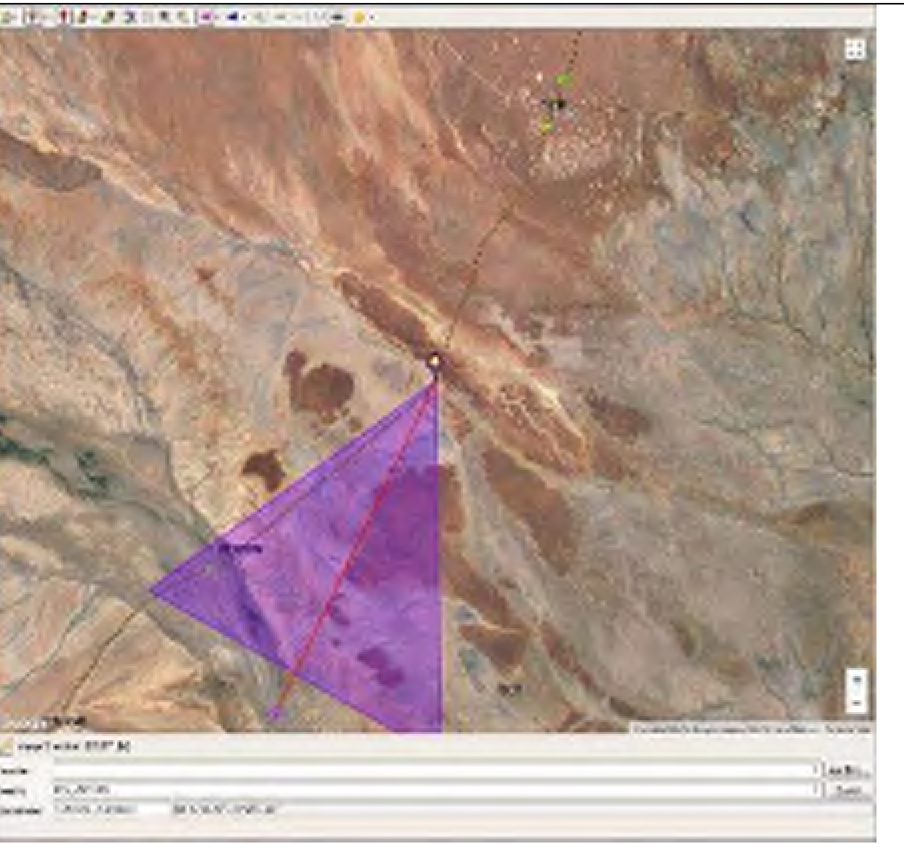
Description: Flooded section on the lhs of the drift.
Coordinates: N1°17'31.20" E39°50'36.28"
Altitude: 219.4 m

Point 48.



Description: Flooded section on the rhs of the drift.
Coordinates: N1°17'30.76" E39°50'35.88"
Altitude: 220.0 m

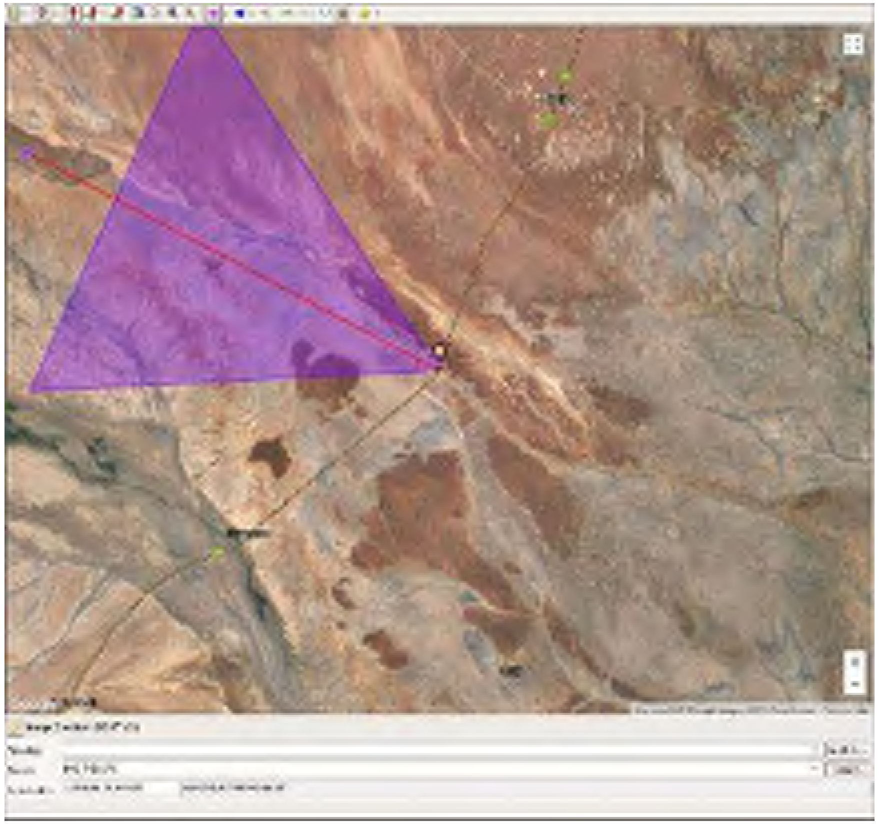
Point 48



Description: Flooded section on the lhs of the drift.
Coordinates: N1°17'30.51" E39°50'36.02"
Altitude: 220.5 m

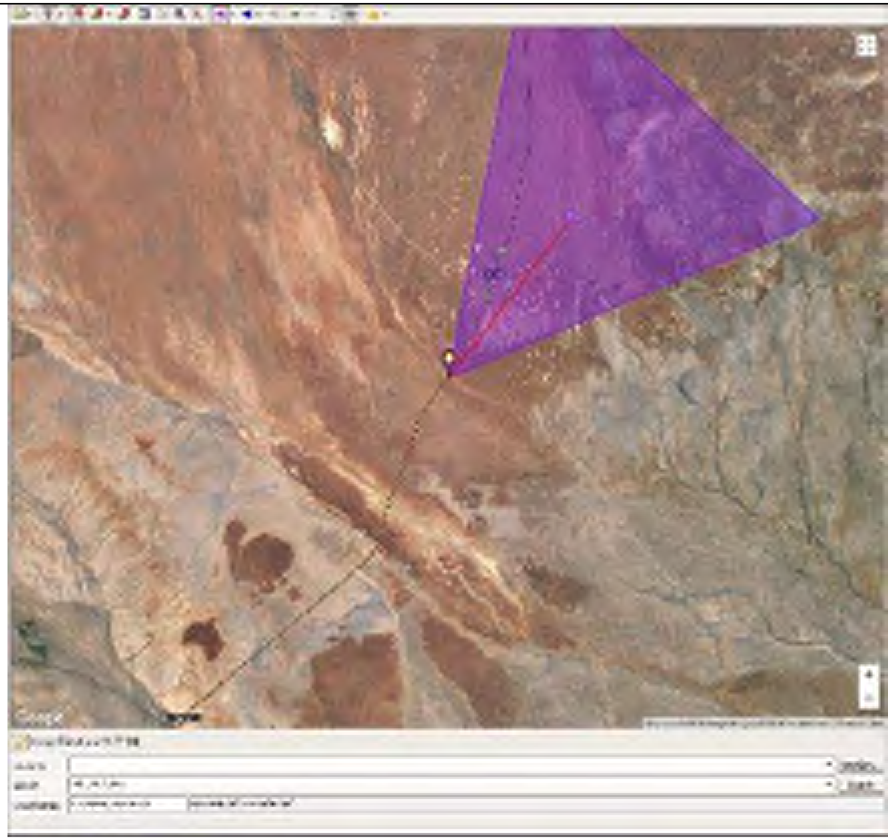
Point 48

sectioin



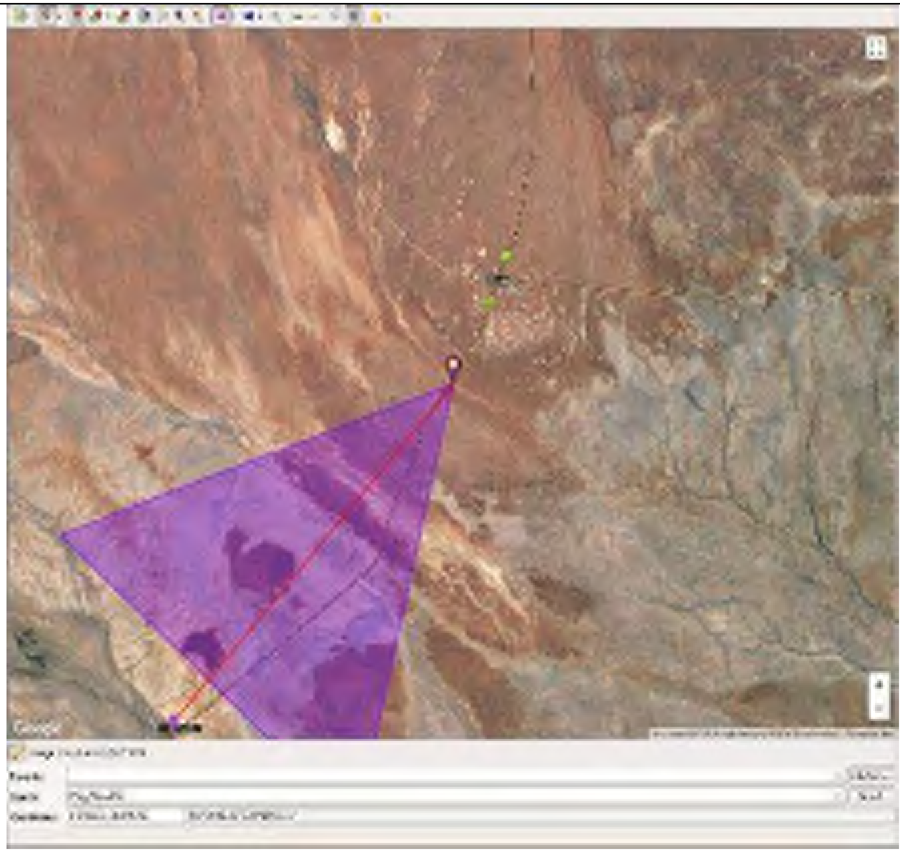
Description: Forward view of the Gravel road on a flat area after the long drift at Lagh Boghal.
Coordinates: N1°34'45.28" E39°58'43.58"
Altitude: 224.1 m

Point 49



Description: Backward view of the Gravel road on a flat area.
Coordinates: N1°34'45.21" E39°58'43.51"
Altitude: 224.1 m

Point 49

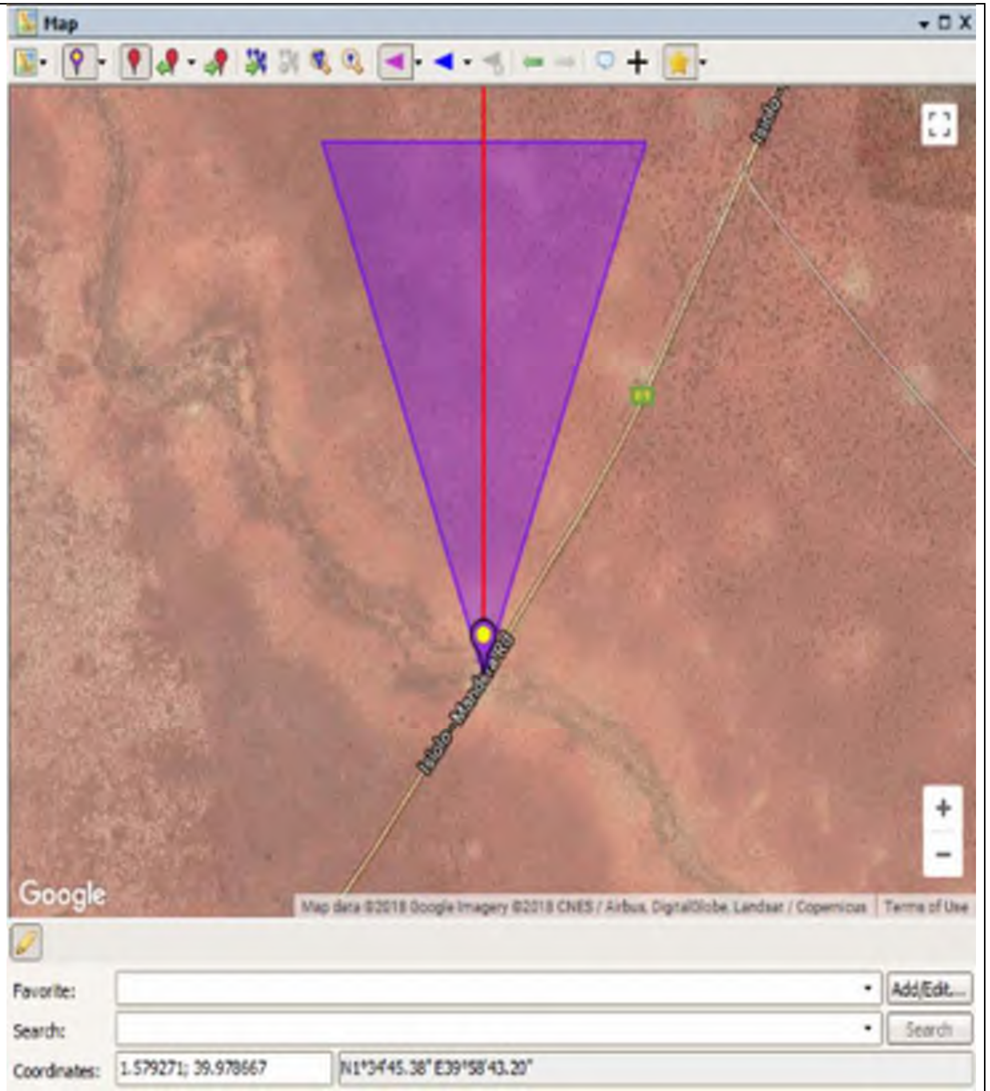


Description: Flat area with no drainage structure and it seems to experience stagnation of water in rainy seasons with photo taken in the forward direction

Coordinates: N1°34'45.38" E39°58'43.20"

Altitude: 214m

Point 50

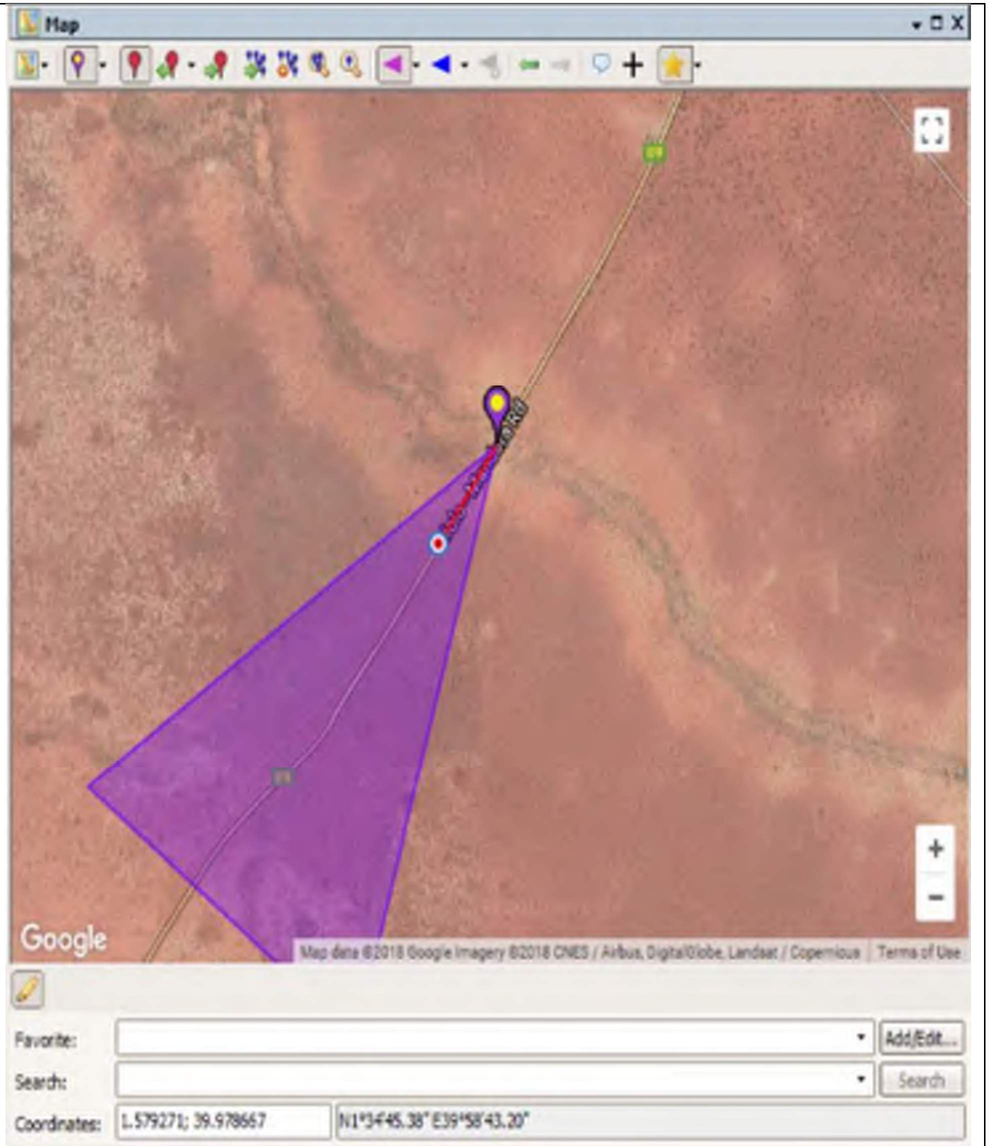


Description: Flat plain area with no drainage structure and it seems to experience stagnation of water in rainy seasons with photo taken in the backward direction

Coordinates: N1°34'45.38" E39°58'43.20"

Altitude: 214m

Point 50

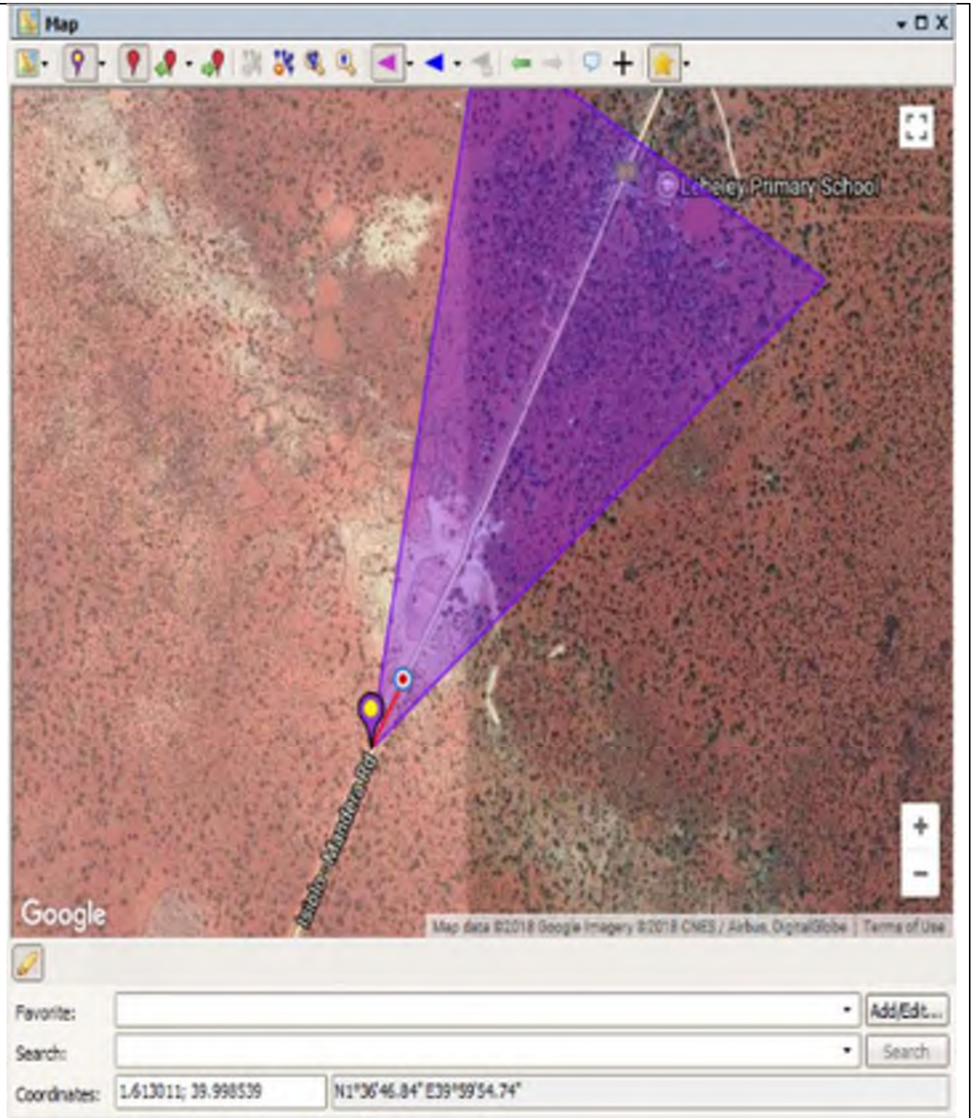


Description: low flat area filled with murram for a stretch of about 2km with photo taken in the forward direction

Coordinates: N1°36'46.84" E39°59'54.74"

Altitude: 190m

Point 51

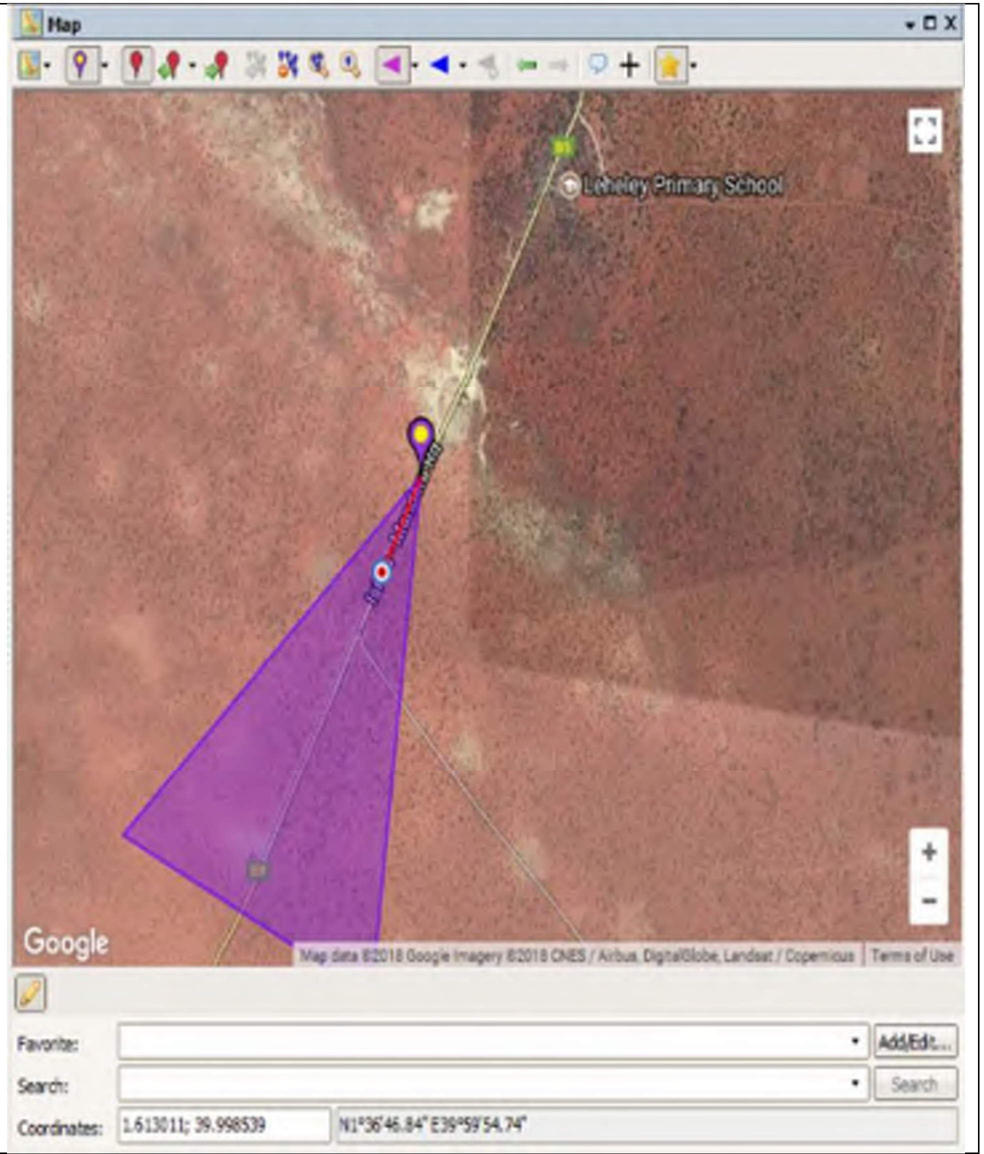


Description: low flat area filled with murram for a stretch of about 2km with photo taken in the backward direction

Coordinates: N1°36'46.84" E39°59'54.74"

Altitude: 190m

Point 51

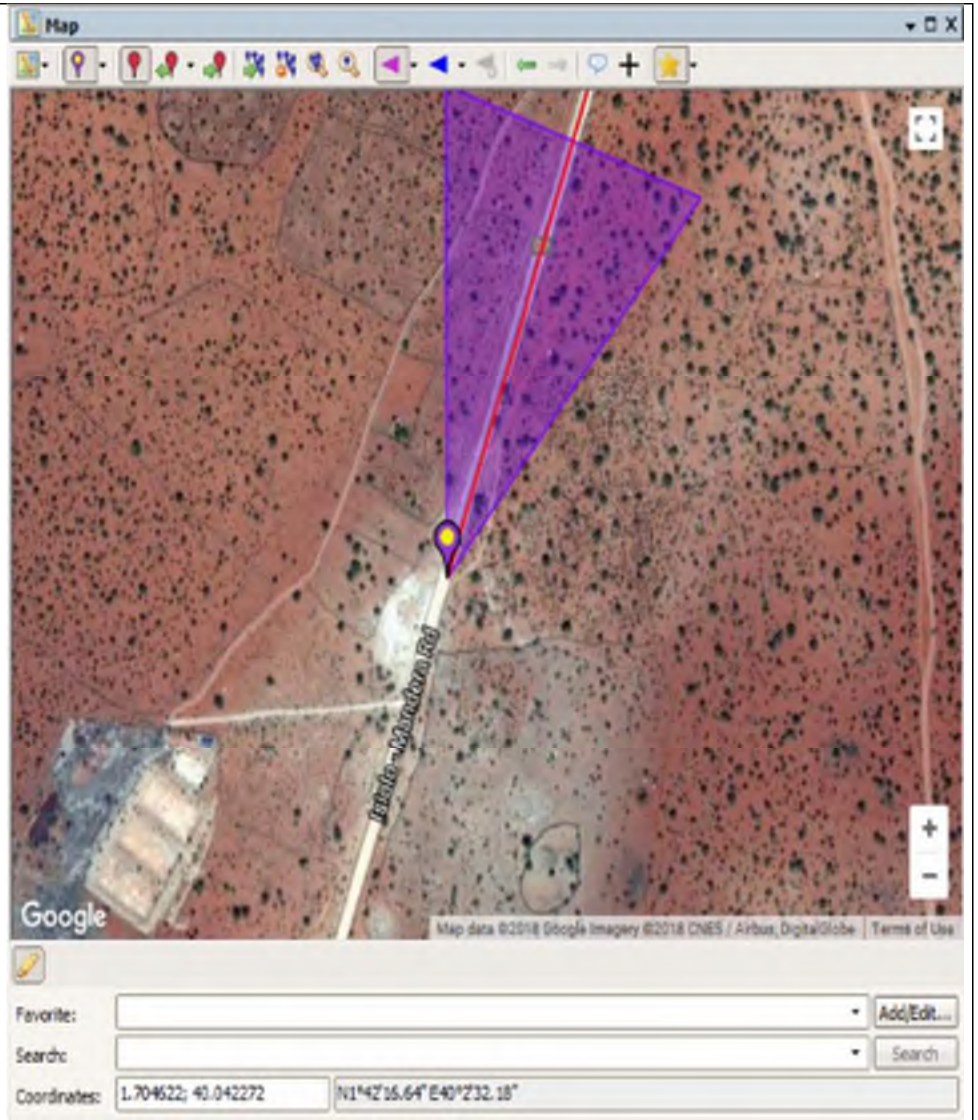


Description: Beginning of tarmac road and the area is relatively flat with photo taken in the forward direction towards Wajir town

Coordinates: N1°42'16.64" E40°2'32.18"

Altitude: 213m

Point 52

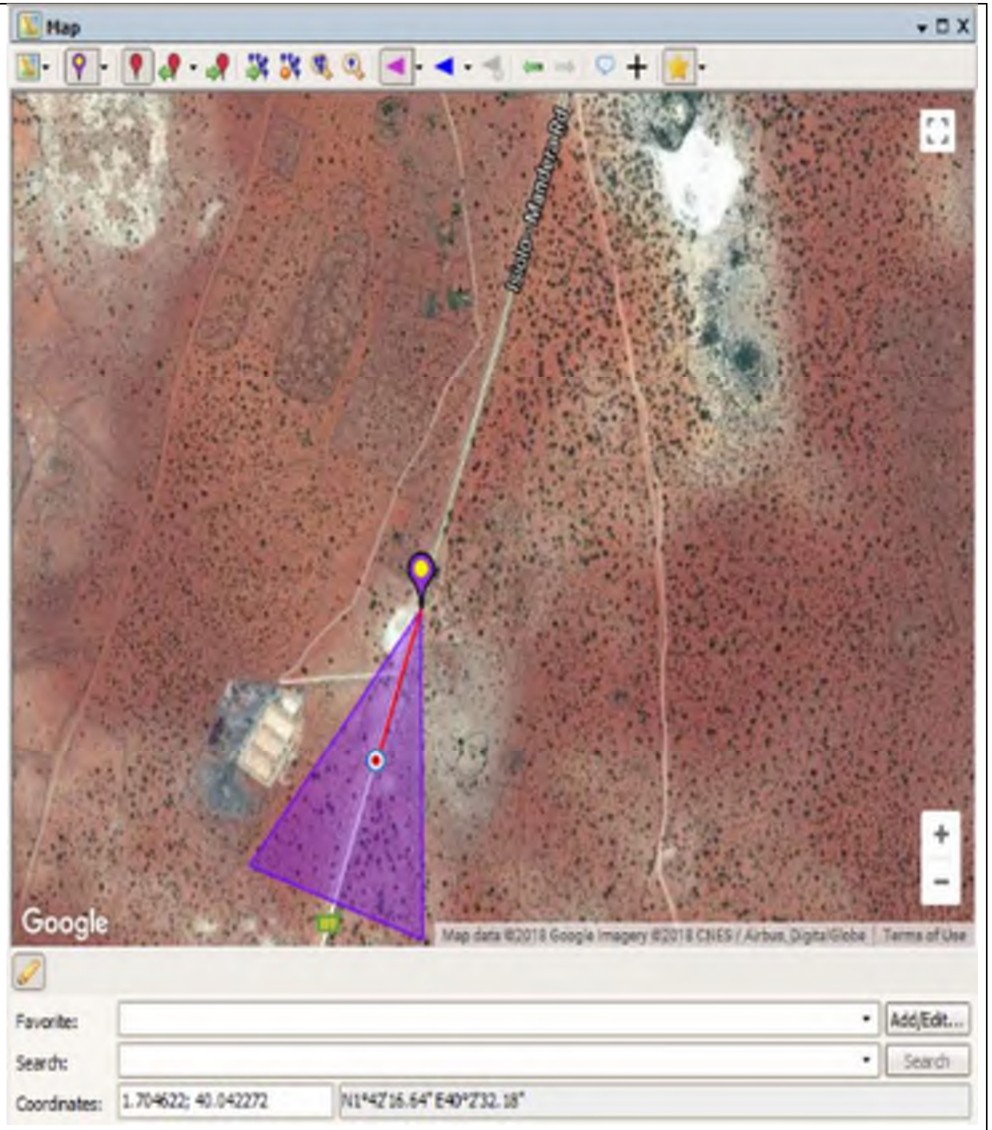


Description: Backward view at the beginning of tarmac road and the area is relatively flat with photo taken in the backward direction

Coordinates: N1°42'16.64" E40°2'32.18"

Altitude: 213m

Point 52

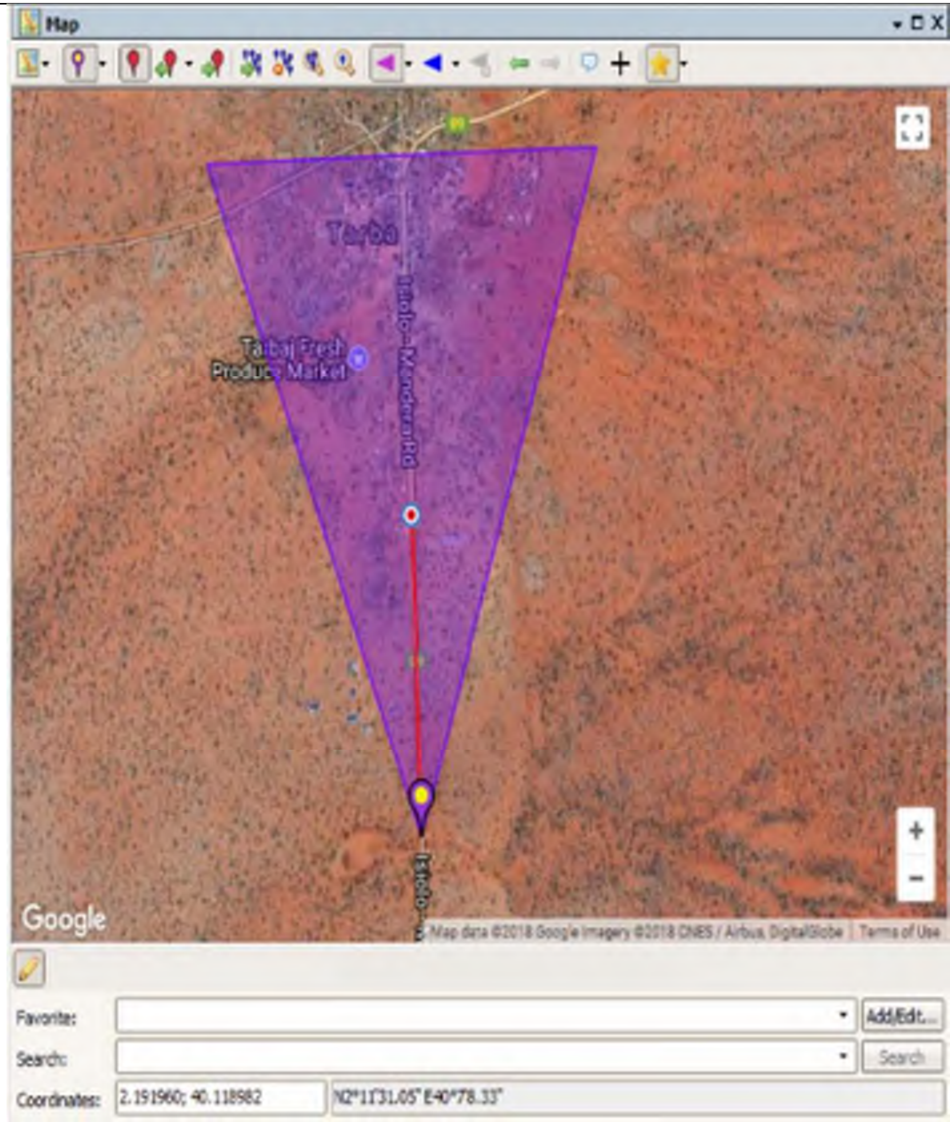


Description: drift section that is dry with sand on either side (tarbaj centre) with photo taken in the forward direction

Coordinates: N2°11'31.05" E40°7'8.33"

Altitude: 357m

Point 53

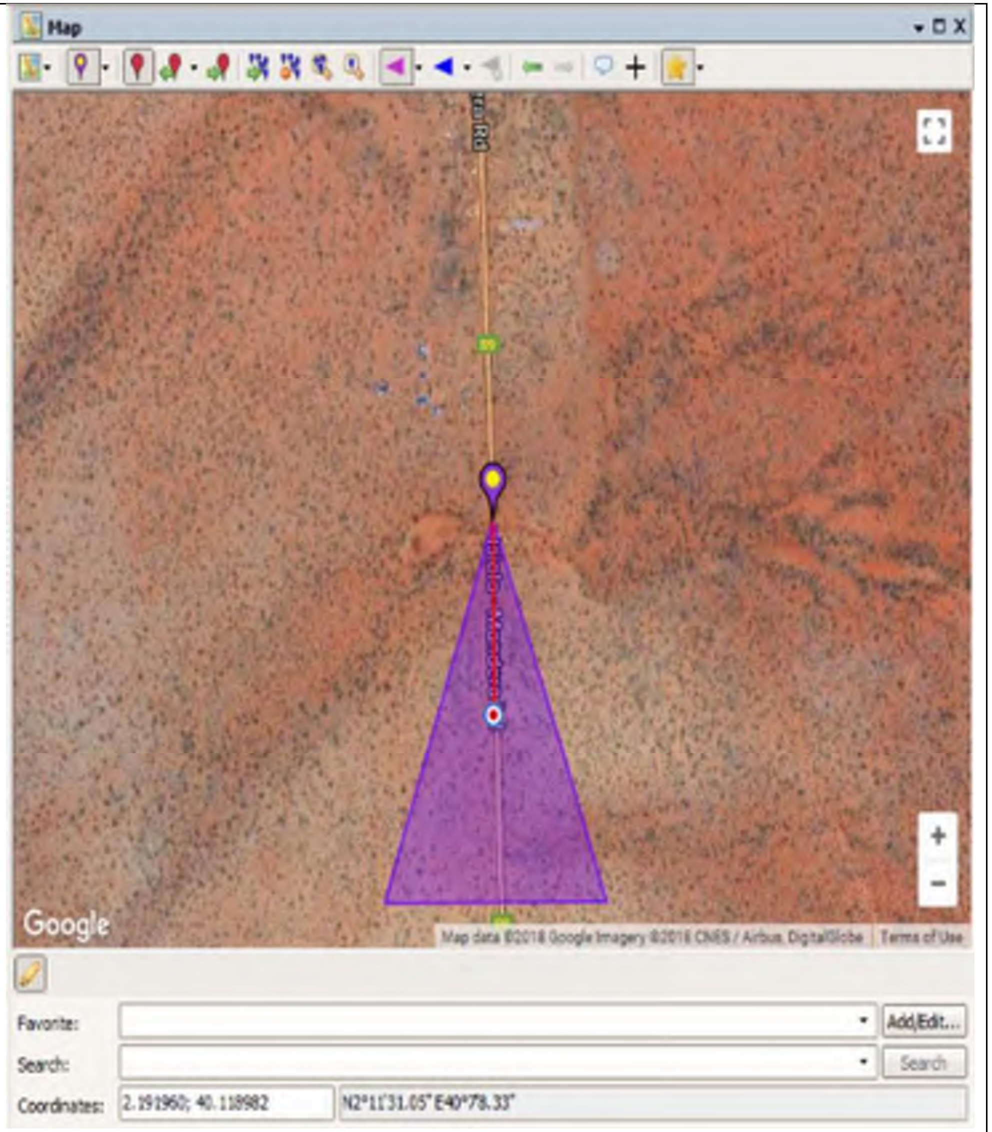


Description: drift section that is dry with sand on either side (tarbaj centre) with photo taken in the backward direction

Coordinates: N2°11'31.05" E40°7'8.33"

Altitude: 357m

Point 53



Description: twin pipe culvert of 900mm diameter silted quarter way with sand on both sides of the road showing the RHS culvert with photo taken towards left side

Coordinates: N2°14'19.74" E40°11'41.01"

Altitude: 422m

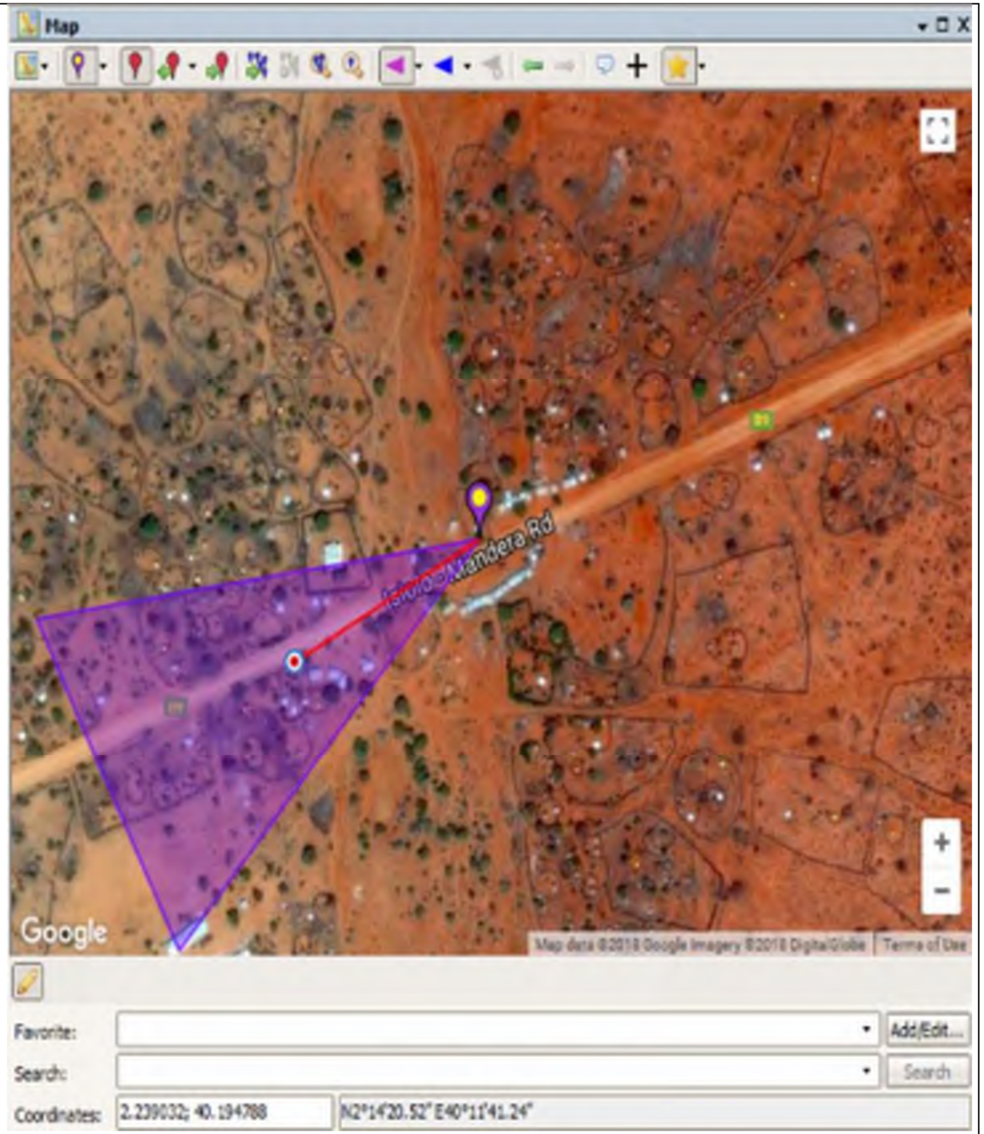
Point 54

Description: Backward view of the approach to the twin pipe culverts of 900mm diameter.

Coordinates: N2°14'20.52" E40°11'41.24"

Altitude: 400m

Point 54



Description: drift section with lots of sand on riverbed on either side of the road with photo taken towards left hand side

Coordinates: N2°15'45.77" E40°15'16.54"

Altitude: 472m

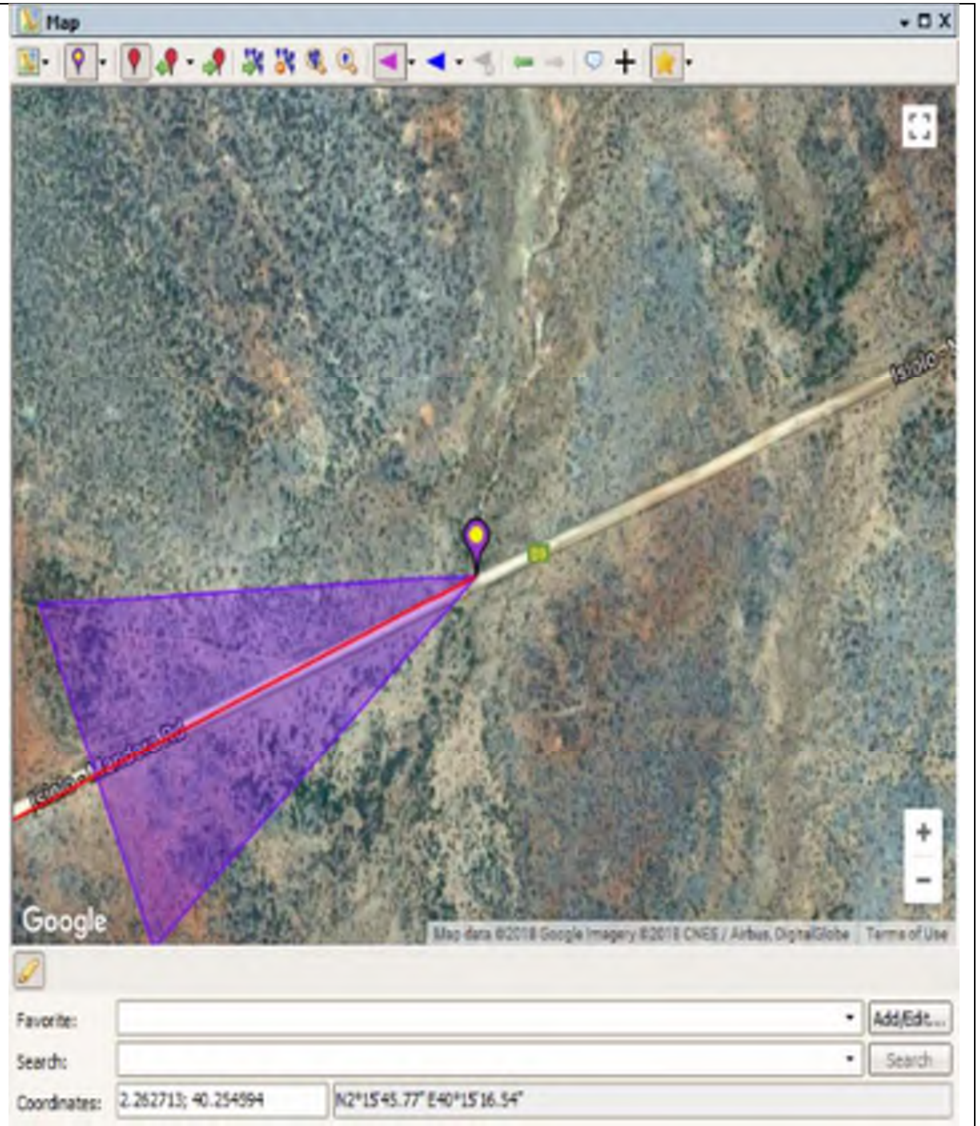
Point 55

Description: drift section with lots of sand on riverbed on either side of the road with photo taken in the backward direction

Coordinates: N2°15'45.77" E40°15'16.54"

Altitude: 472m

Point 55



Description: drift section with sand and stones on upstream side and sand on the downstream with photo taken in the backward direction

Coordinates: N2°15'53.58" E40°15'37.15"

Altitude: 461m

Point 56

Description: drift section with sand and stones on upstream side and sand on the downstream with photo taken in the right direction

Coordinates: N2°15'54.03" E40°15'37.55"

Altitude: 461m

Point 56

Description: drift section with sand and stones on upstream side and sand on the downstream with photo taken in the forward direction

Coordinates: N2°15'53.58" E40°15'37.15"

Altitude: 461m

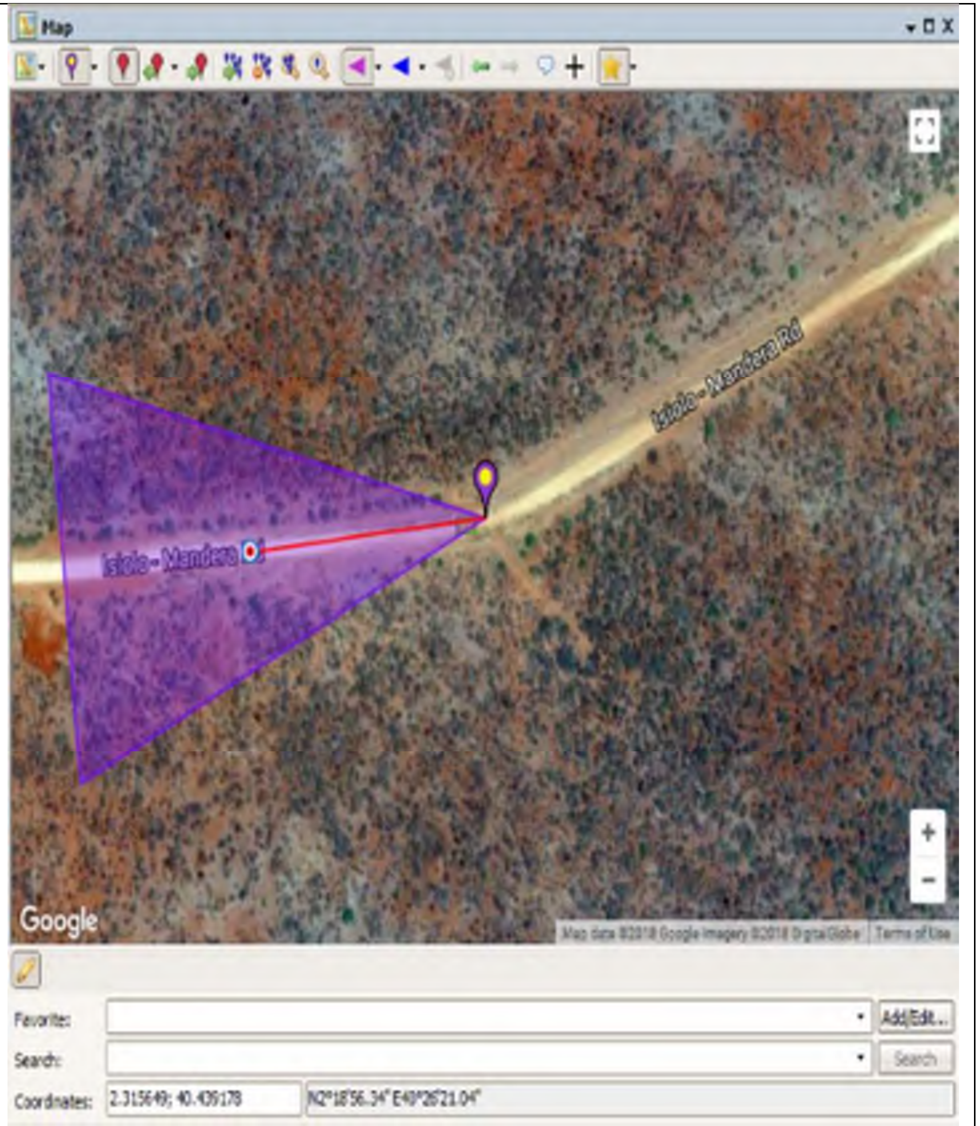
Point 56

Description: Backward view of the approach to a twin culvert section, 900 diameter, with sand riverbed on both upstream and downstream. Culvert has no siltation

Coordinates: N2°18'56.34" E40°26'21.04"

Altitude: 423m

Point 58



Description: Forward view of the approach to a twin culvert section, 900 diameter, with sand riverbed on both upstream and downstream. Culvert has no siltation

Coordinates: N2°18'56.26" E40°26'21.01"

Altitude: 419m

Point 58

Description: Lhs view of the approach to a twin culvert section, 900 diameter, with sand riverbed on both upstream and downstream. Culvert has no siltation

Coordinates: N2°18'56.34" E40°26'21.04"

Altitude: 423m

Point 58

Description: Rhs view of the approach to a twin culvert section, 900 diameter, with sand riverbed on both upstream and downstream. Culvert has no siltation

Coordinates: N2°18'56.34" E40°26'21.04"

Altitude: 423m

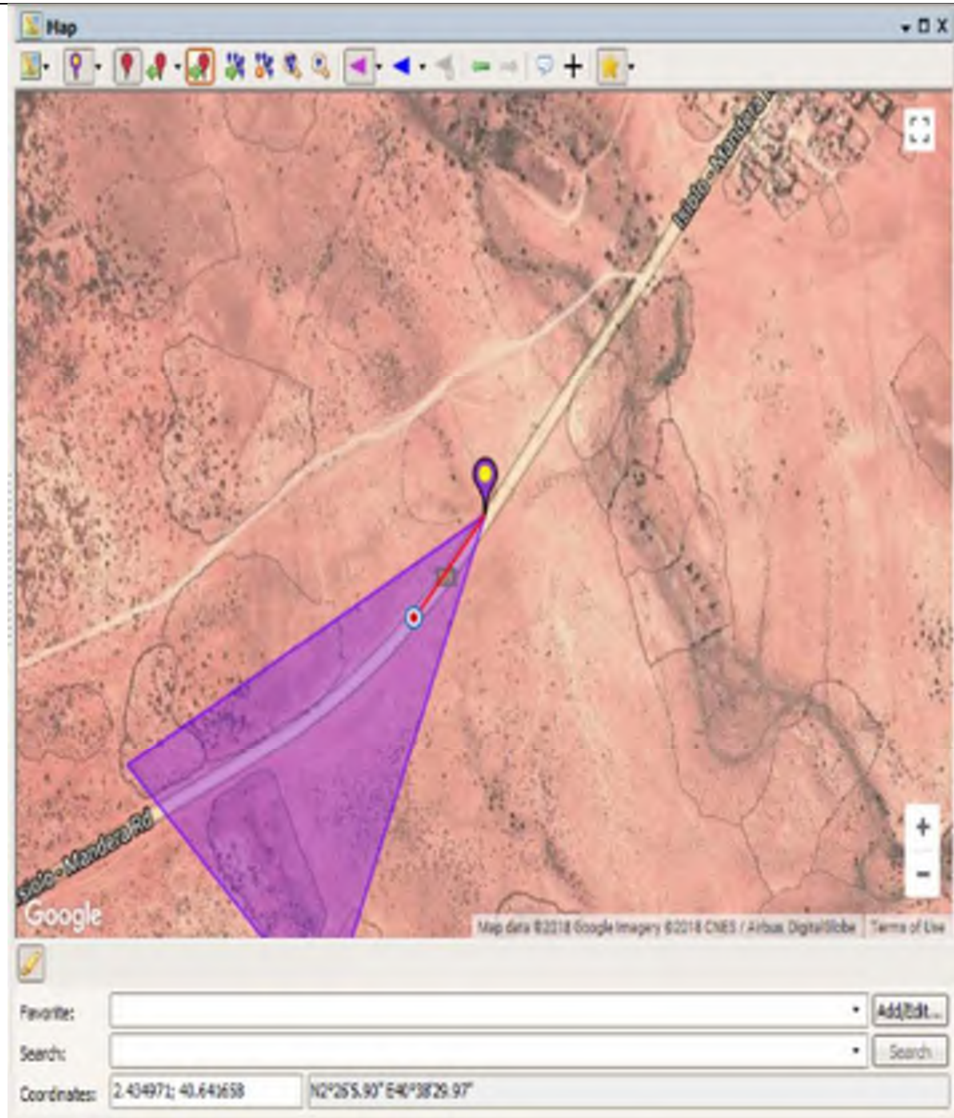
Point 58

Description: Backward view of road section with huge deposits of sand.

Coordinates: N2°26'5.90" E40°38'29.97"

Altitude: 320m

Point 59 depression section

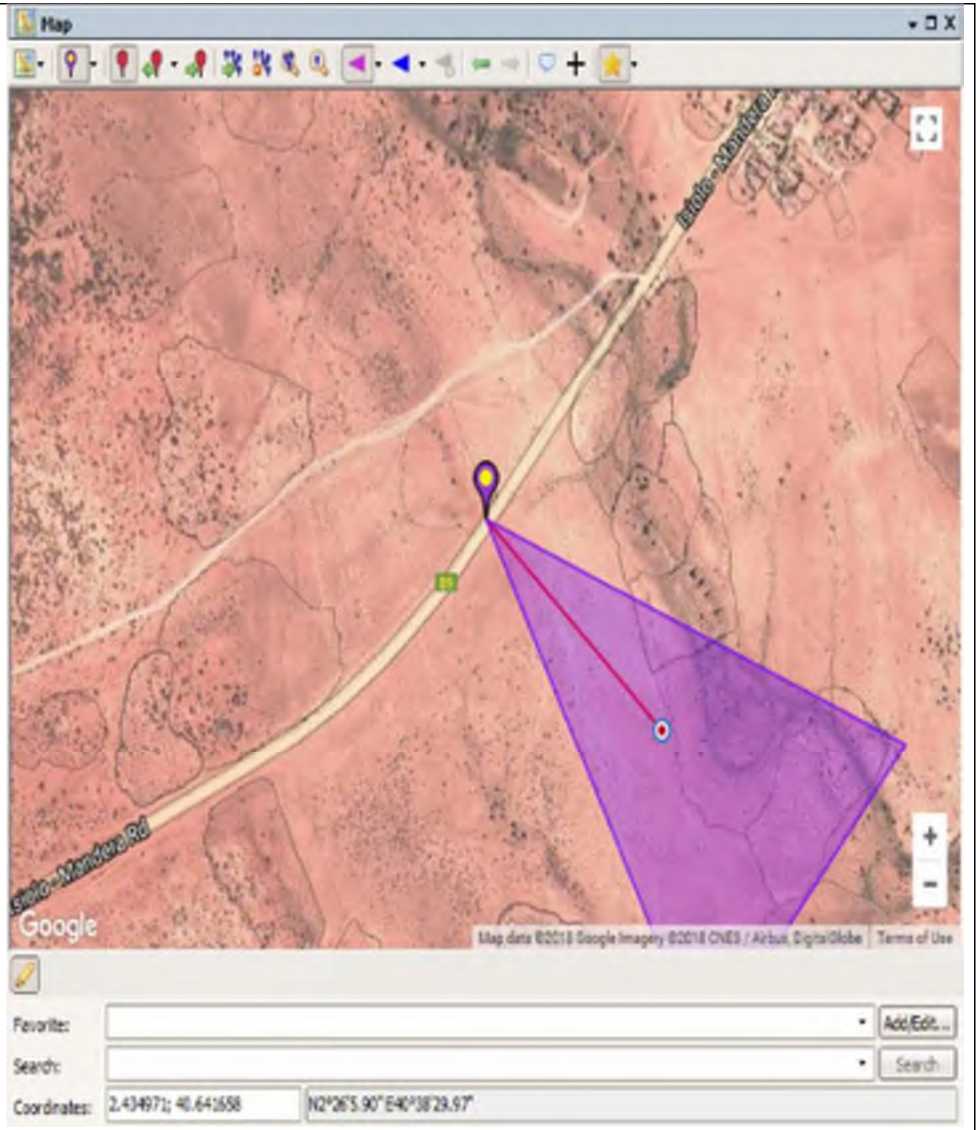


Description: Rhs view of road section with huge deposits of sand.

Coordinates: N2°26'5.90" E40°38'29.97"

Altitude: 320m

Point 59 depression section

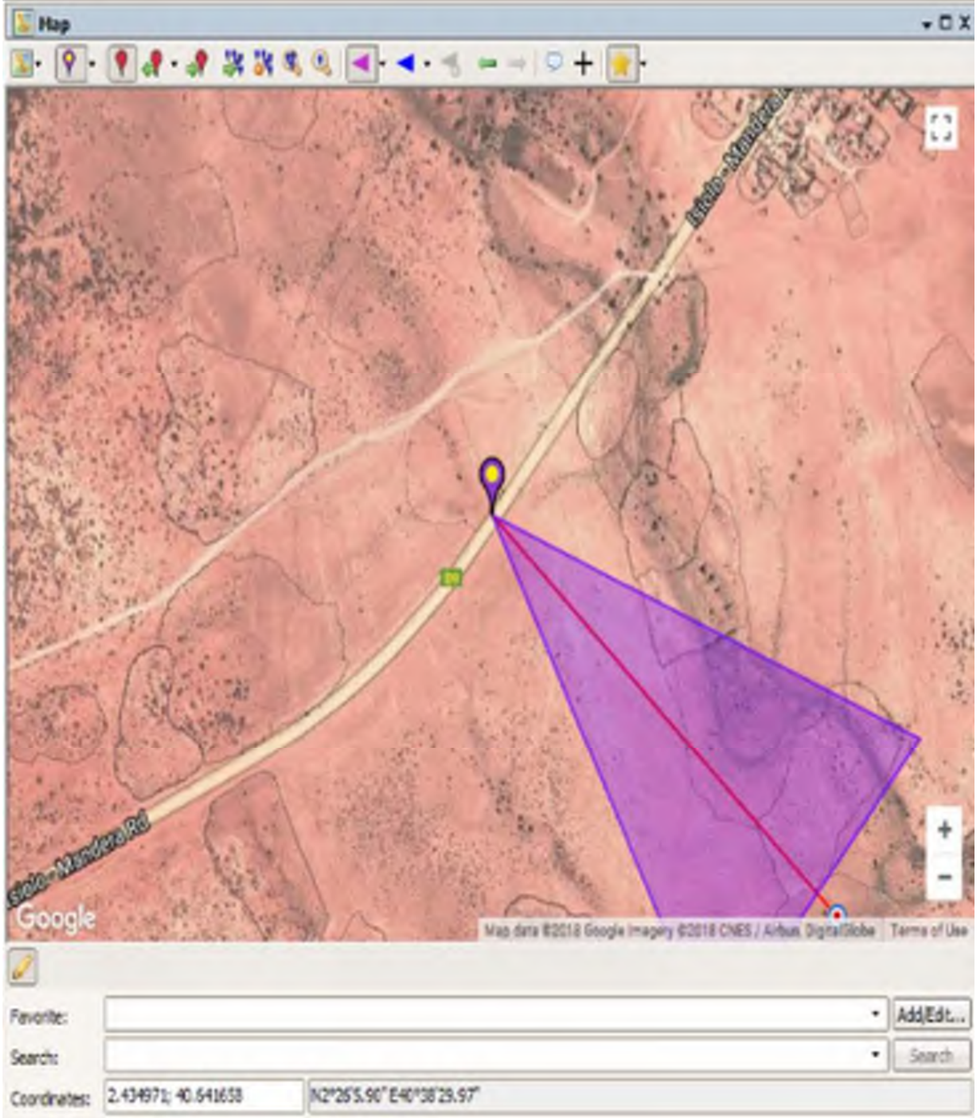


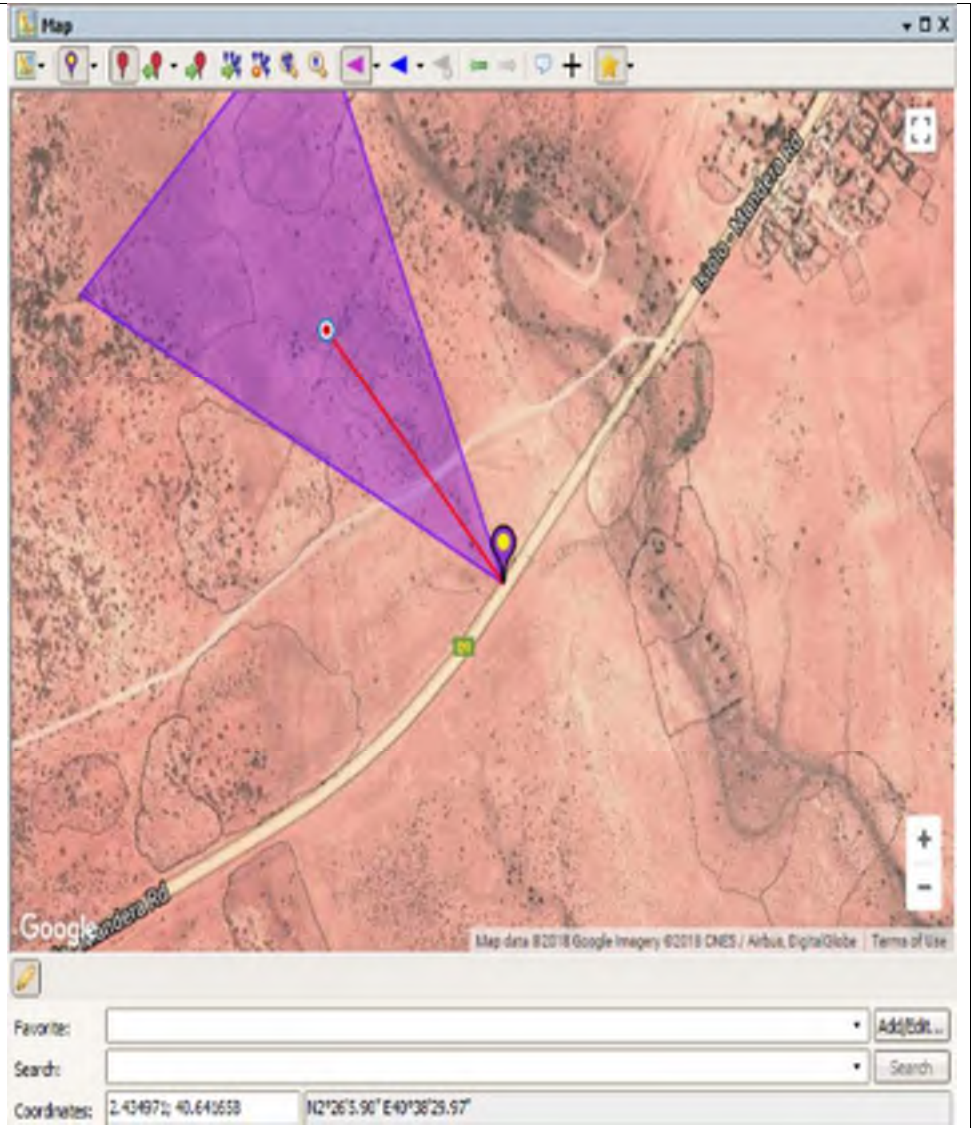
Description: culvert section, 900mm diameter with no siltation with photo showing LHS of culvert and photo direction towards right side of road

Coordinates: N2°26'5.90" E40°38'29.97"

Altitude: 320m

Point 59 Culvert section





Description: culvert section 900mm diameter with no siltation showing the RHS of culvert with photo taken towards the left direction

Coordinates: N2°26'5.90" E40°38'29.97"

Altitude: 320m

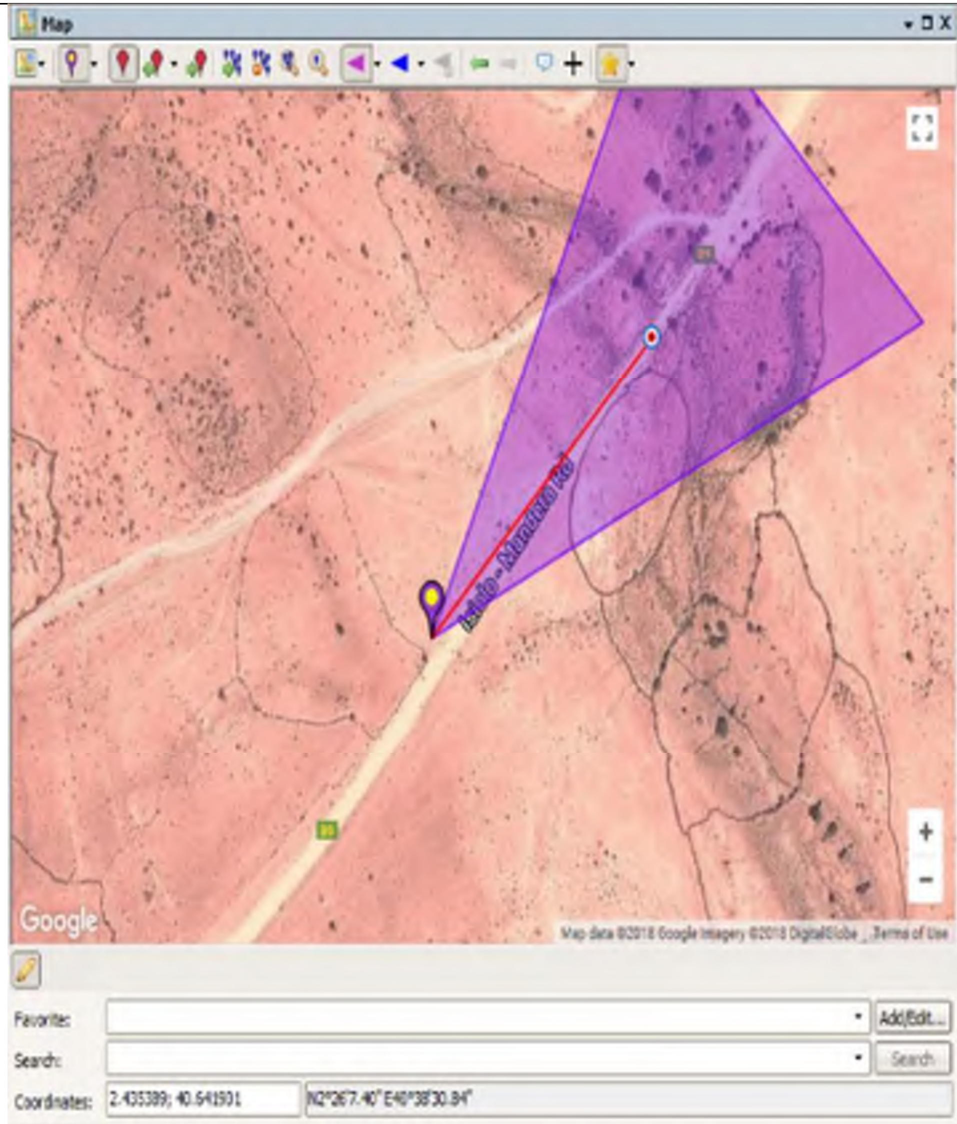
Point 59 culvert section

Description: Forward of approach to a 900mm diameter pipe culvert.

Coordinates: N2°26'7.40" E40°38'30.84"

Altitude: 325m

Point 59

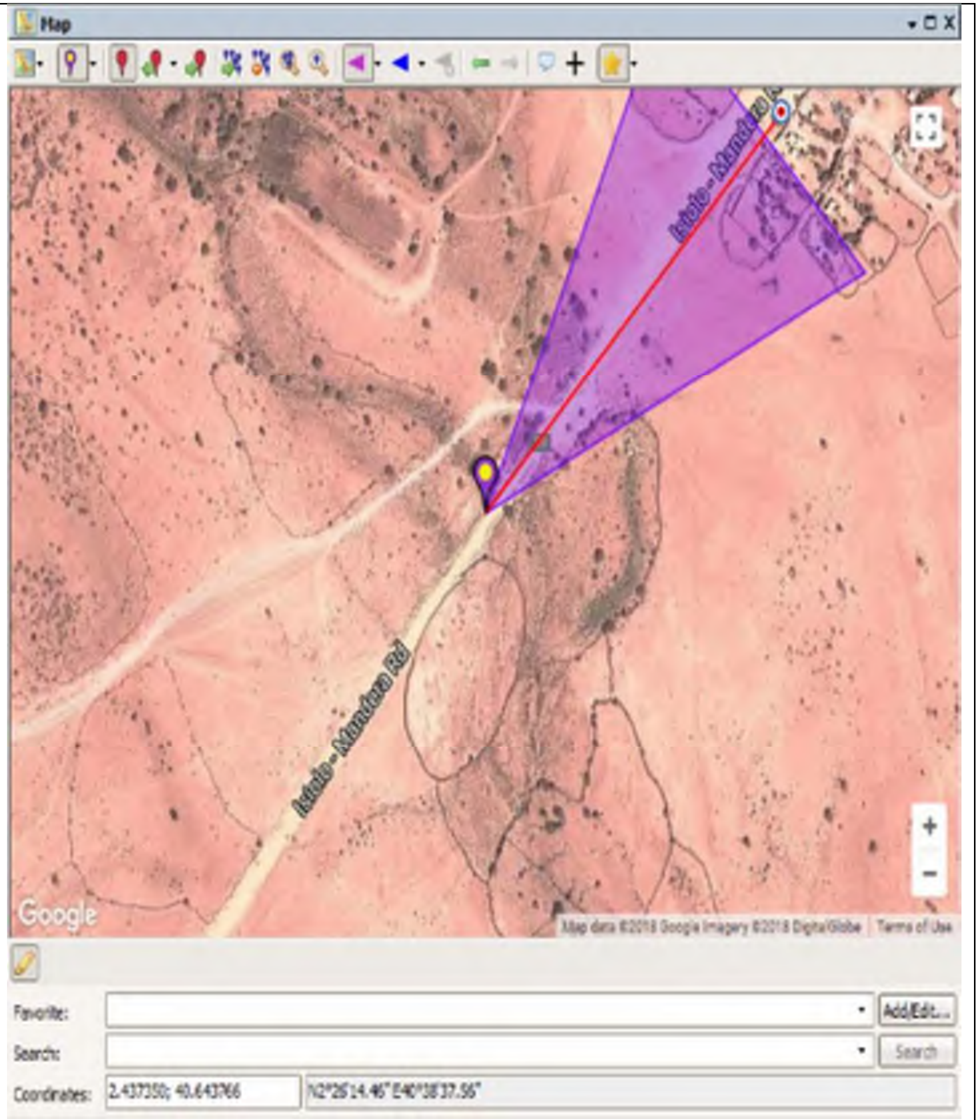


Description: drift section with sand deposits and water stagnated on one side of the drift with photo taken in the forward direction

Coordinates: N2°26'14.46" E40°38'37.56"

Altitude: 311m

Point 60

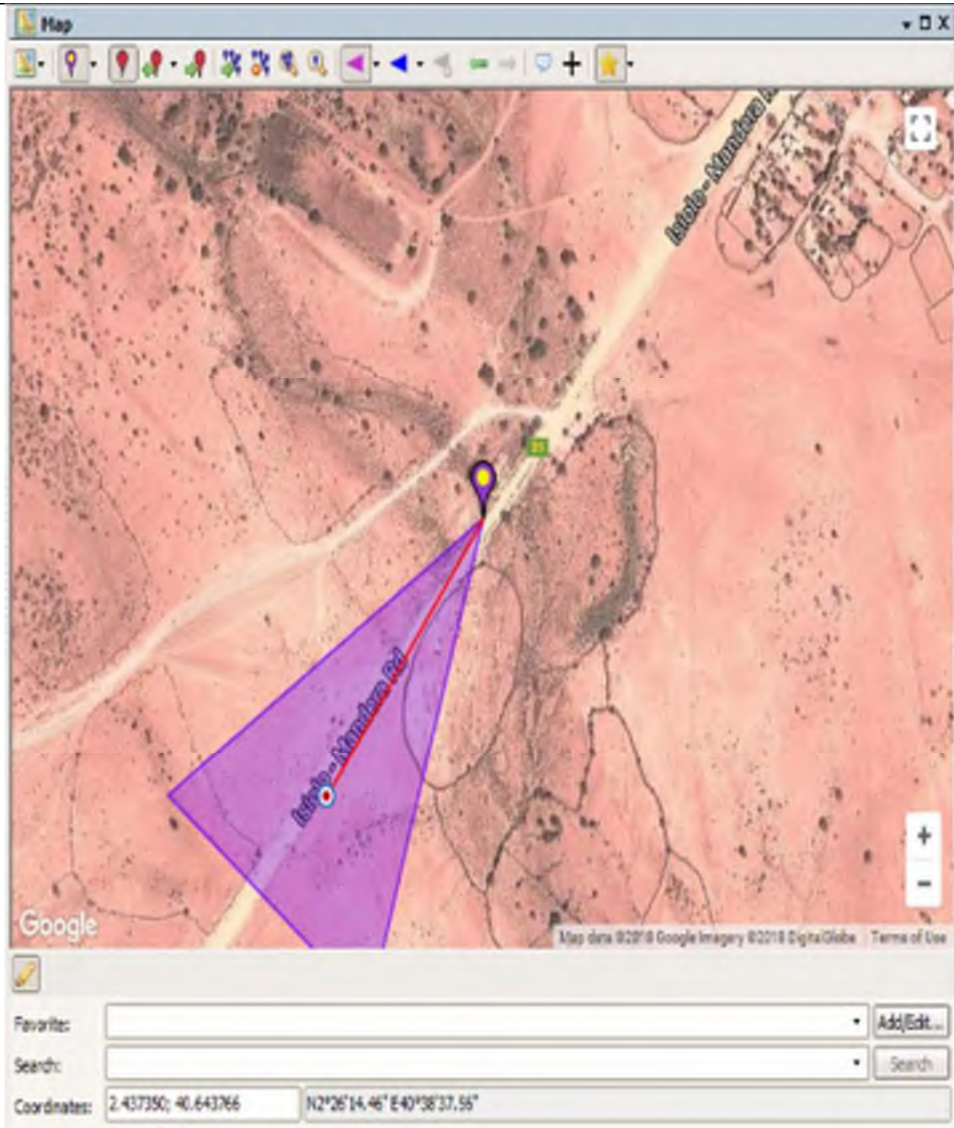


Description: Backward view of a drift section huge sand deposits.

Coordinates: N2°26'14.46" E40°38'37.56"

Altitude: 311m

Point 60

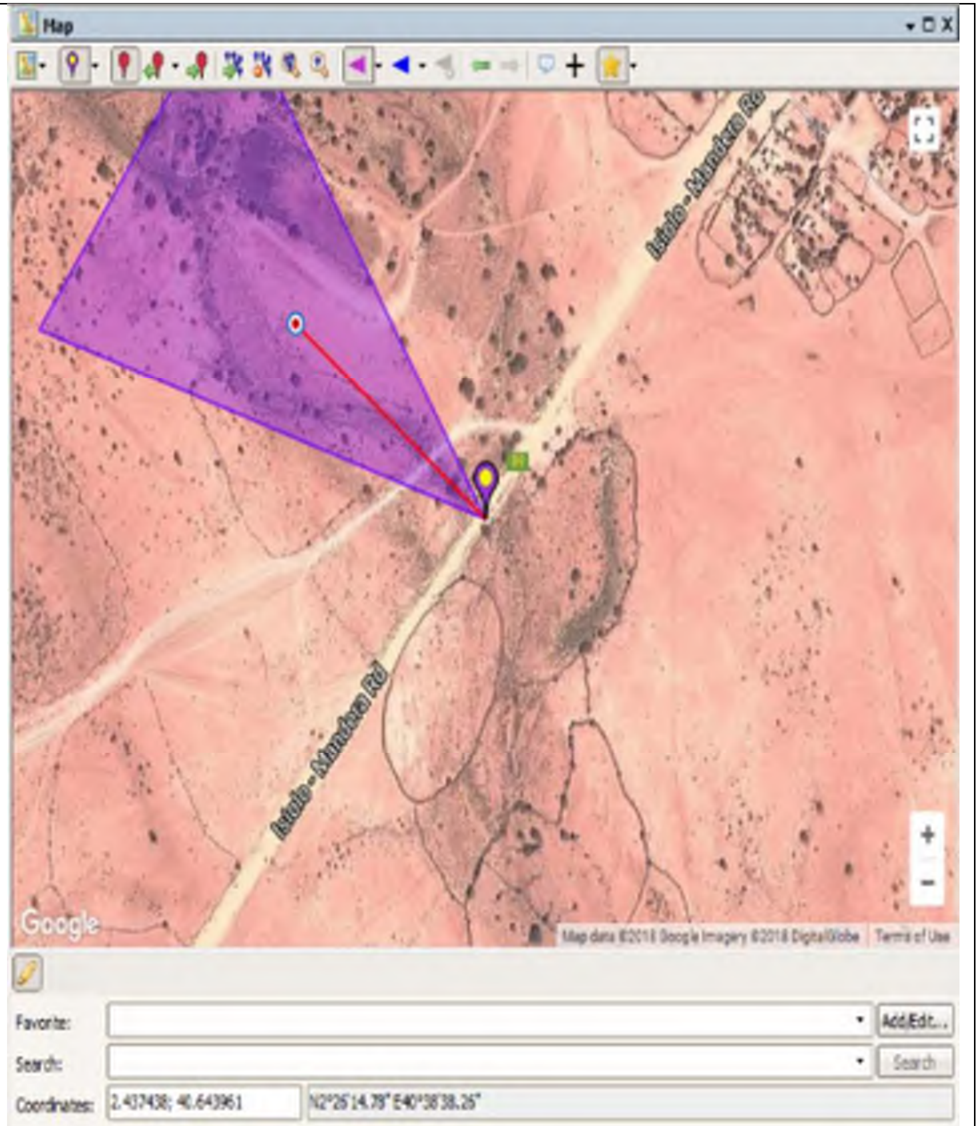


Description: Lhs view of flooded area at the sides of the drift.

Coordinates: N2°26'14.78" E40°38'38.26"

Altitude: 311m

Point 60

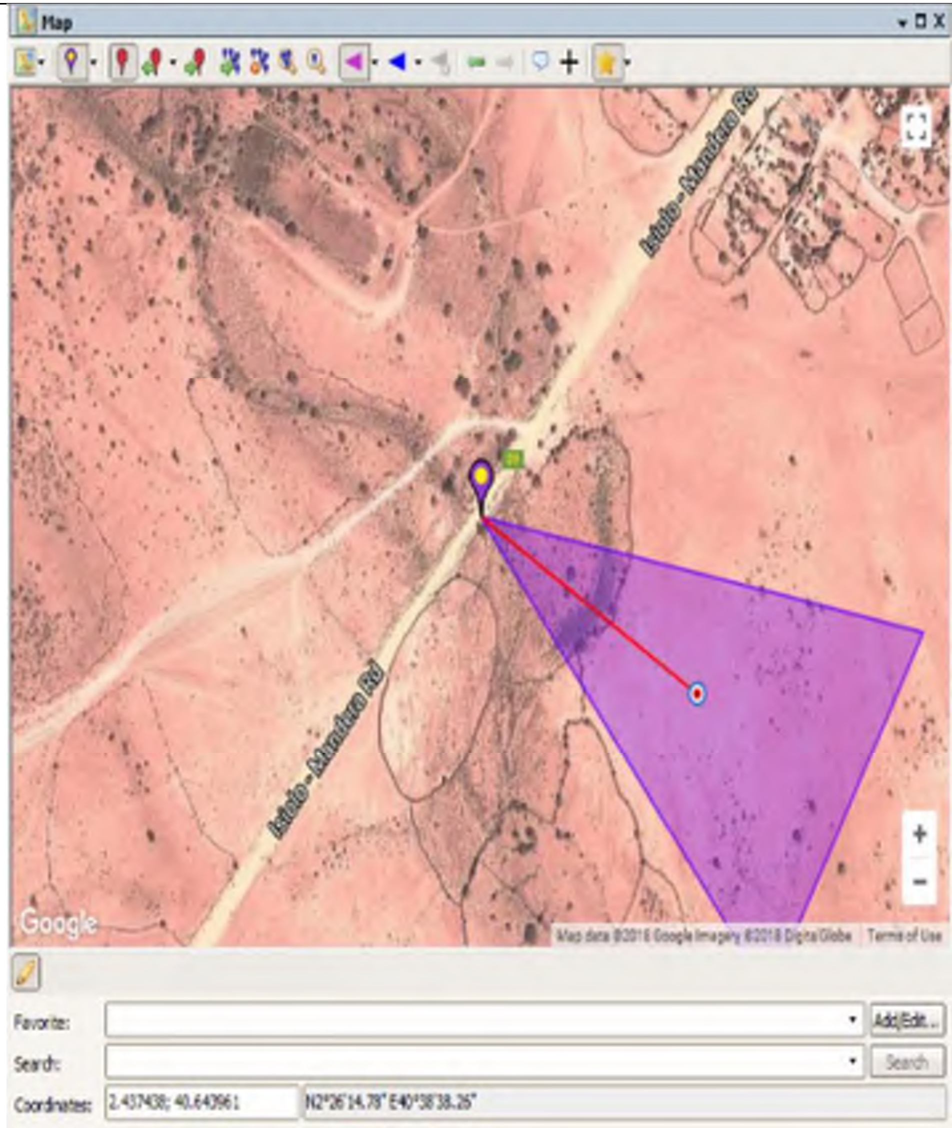


Description: Rhs view of flooded area at the sides of the drift.

Coordinates: N2°26'14.78" E40°38'38.26"

Altitude: 311m

Point 60



Description: single culvert section 900 diameter with road section raised with photo taken in the backward direction

Coordinates: N2°28'12.47" E40°40'22.73"

Altitude: 341m

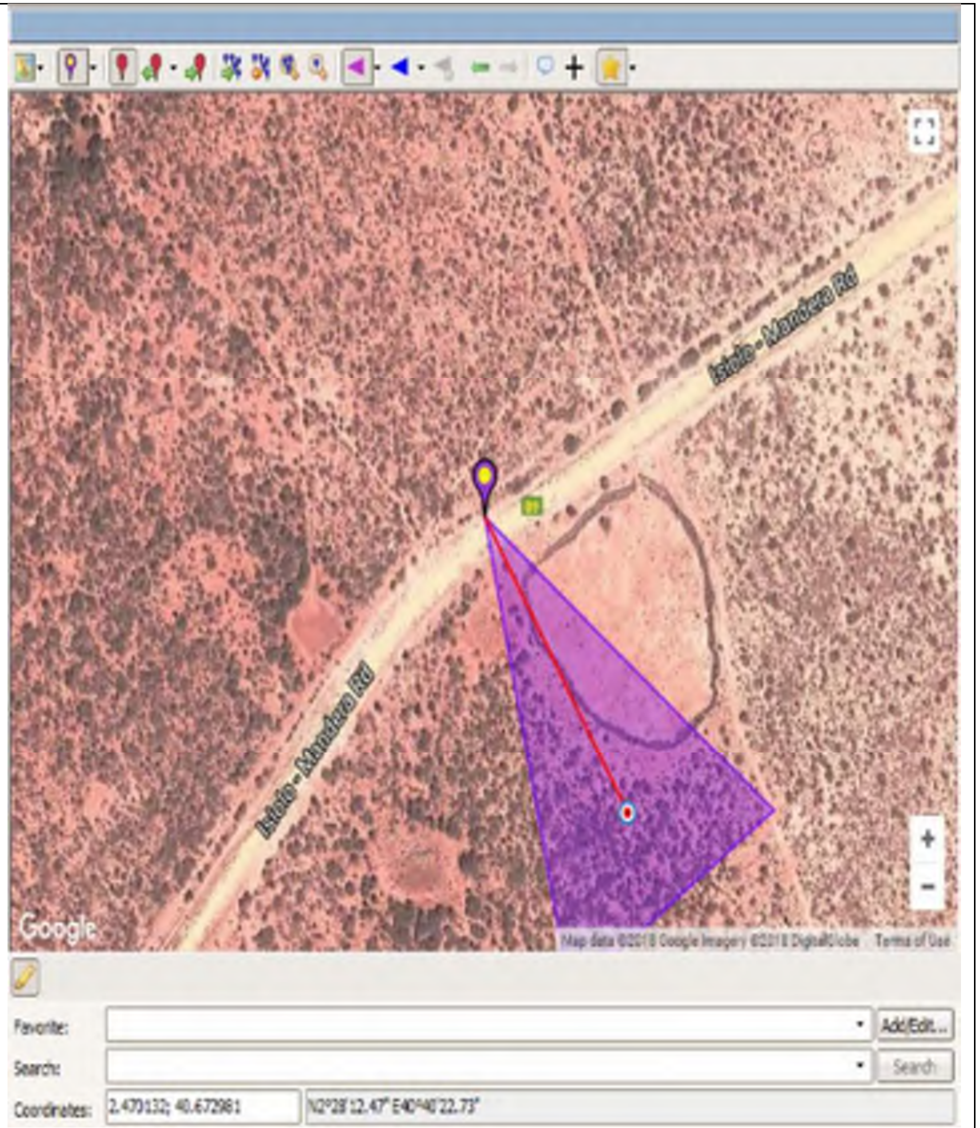
Point 61

Description: single pipe culvert section 900 diameter with no siltation showing the LHS of culvert with photo taken towards the right direction

Coordinates: N2°28'12.47" E40°40'22.73"

Altitude: 341m

Point 61



Description: single pipe culvert section 900 diameter with no siltation showing the RHS of culvert with photo taken towards the left direction

Coordinates: N2°28'12.47" E40°40'22.73"

Altitude: 341m

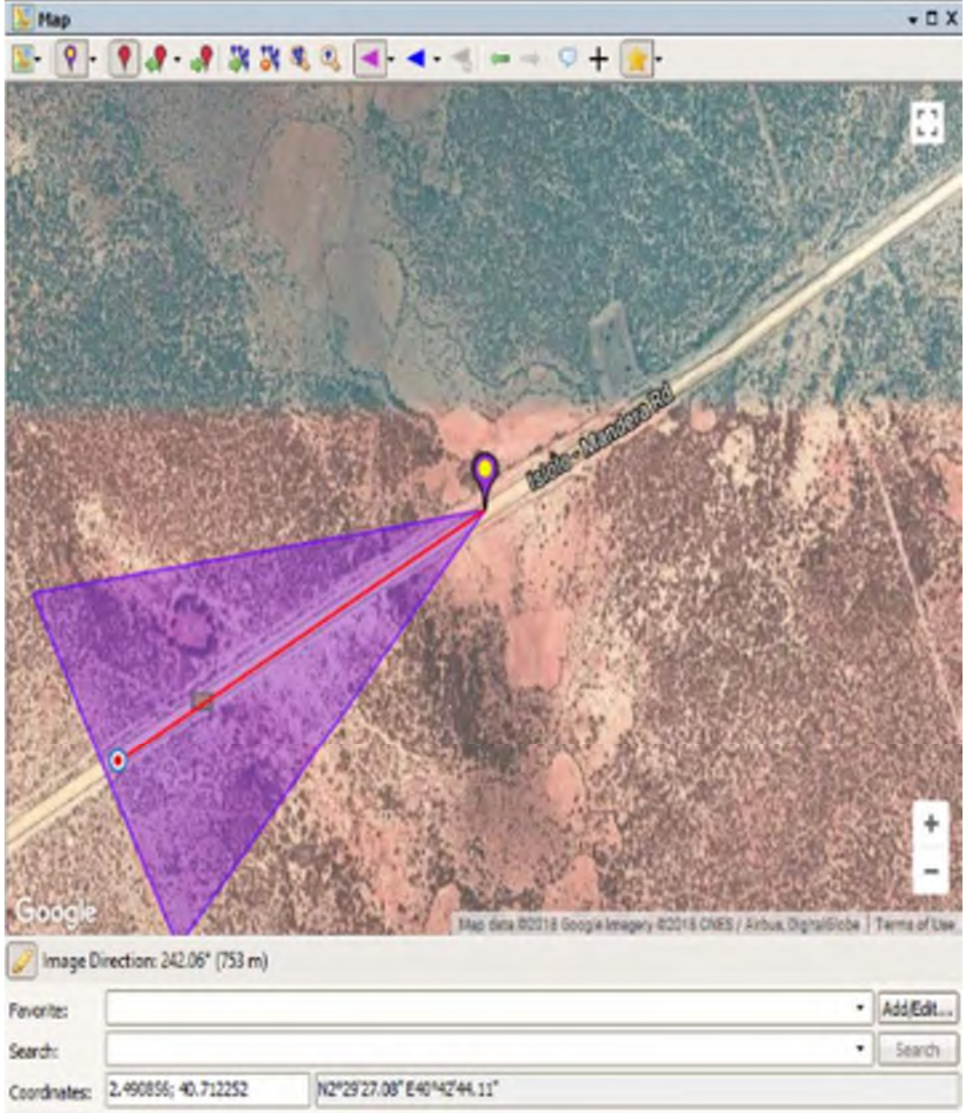
Point 61

Description: twin box culvert section of 6m x 2m with photo taken in the backward direction

Coordinates: N2°29'27.08" E40°42'44.11"

Altitude: 352m

Point 62

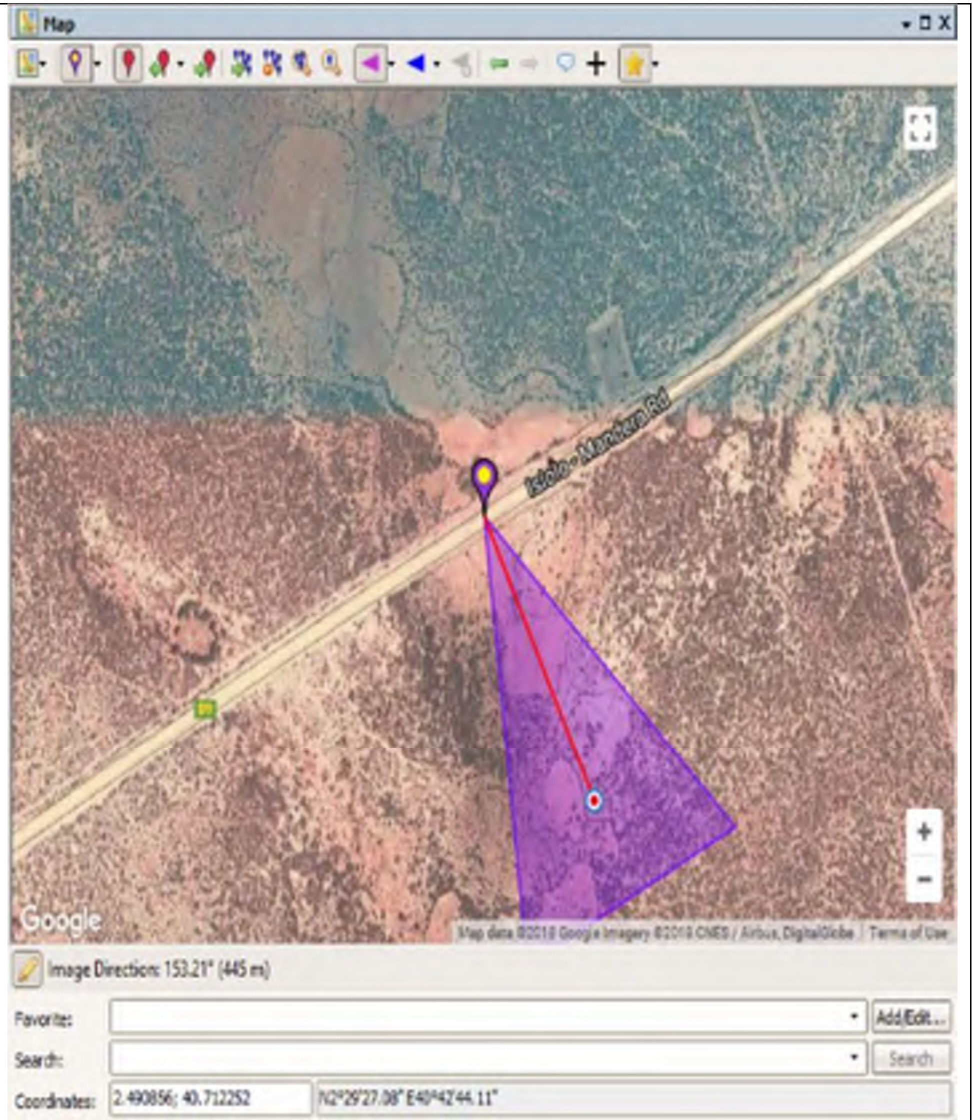


Description: Lhs view of a twin box culvert section of 6 x 2m

Coordinates: N2°29'27.08" E40°42'44.11"

Altitude: 352m

Point 62



Description: Rhs view of a twin box culvert section of 6 x 2m, showing signs of siltation.

Coordinates: N2°29'27.08" E40°42'44.11"

Altitude: 352m

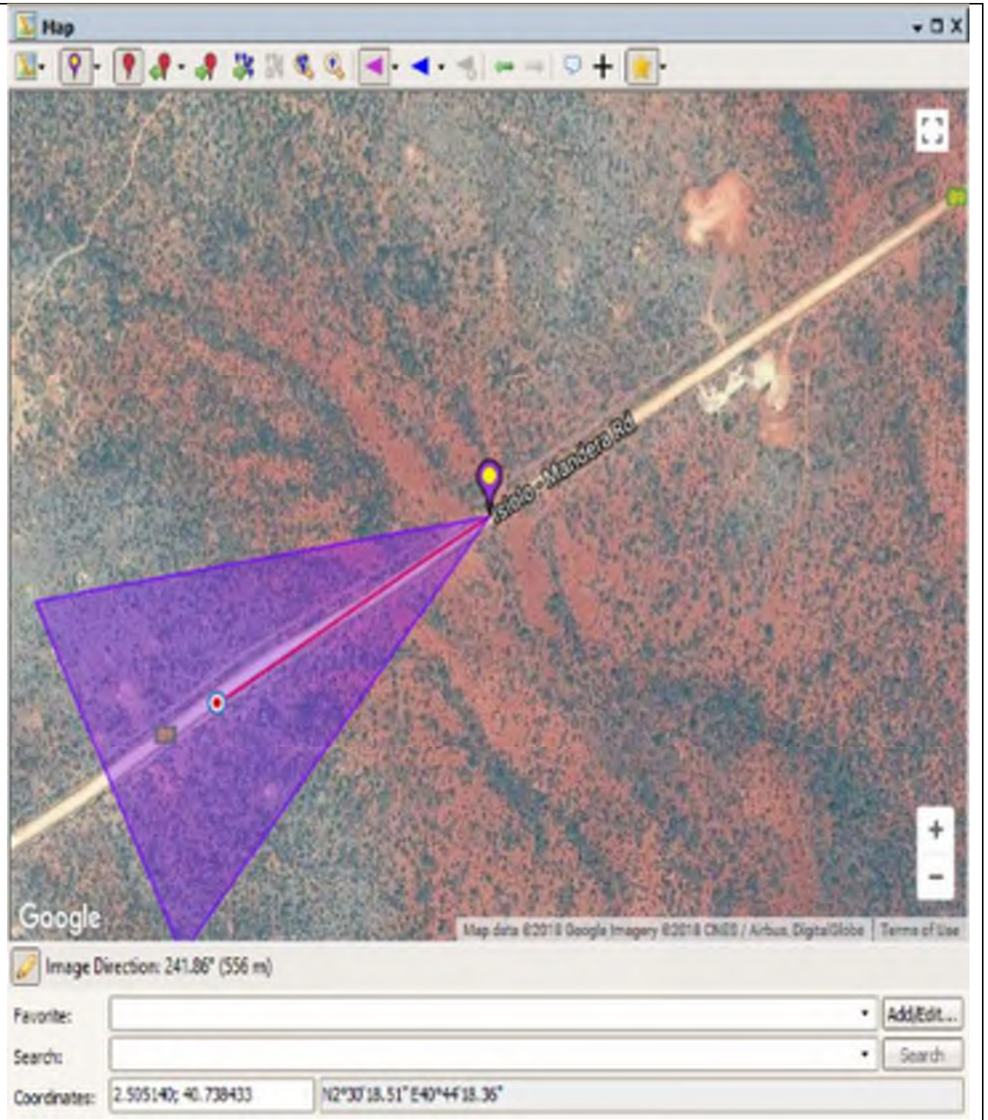
Point 62

Description: drift section of about 20m long with photo taken in the backward direction

Coordinates: N2°30'18.51" E40°44'18.36"

Altitude: 336m

Point 63

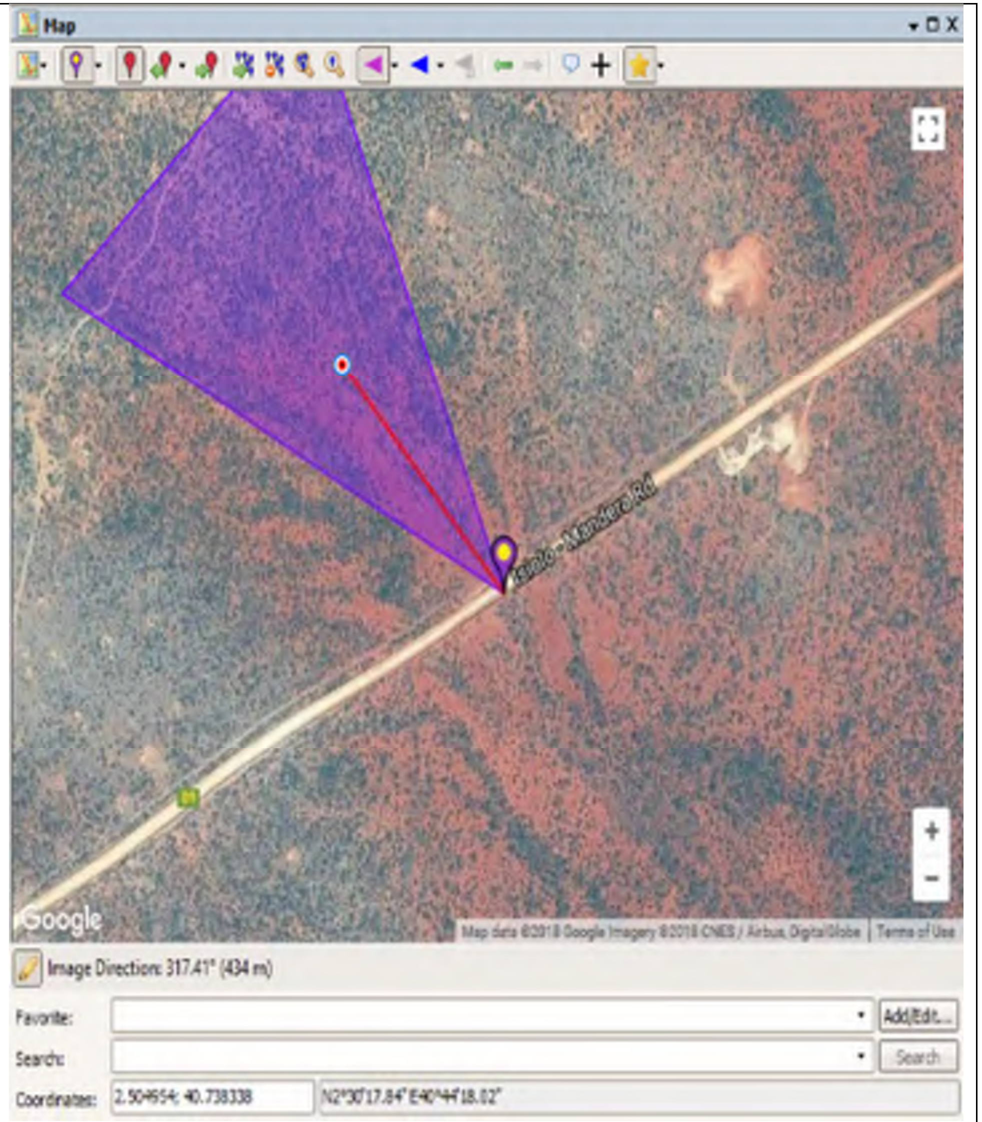


Description: drift section of about 20m long showing signs of scouring, with photo taken towards the left direction

Coordinates: N2°30'17.84" E40°44'18.02"

Altitude: 341m

Point 63

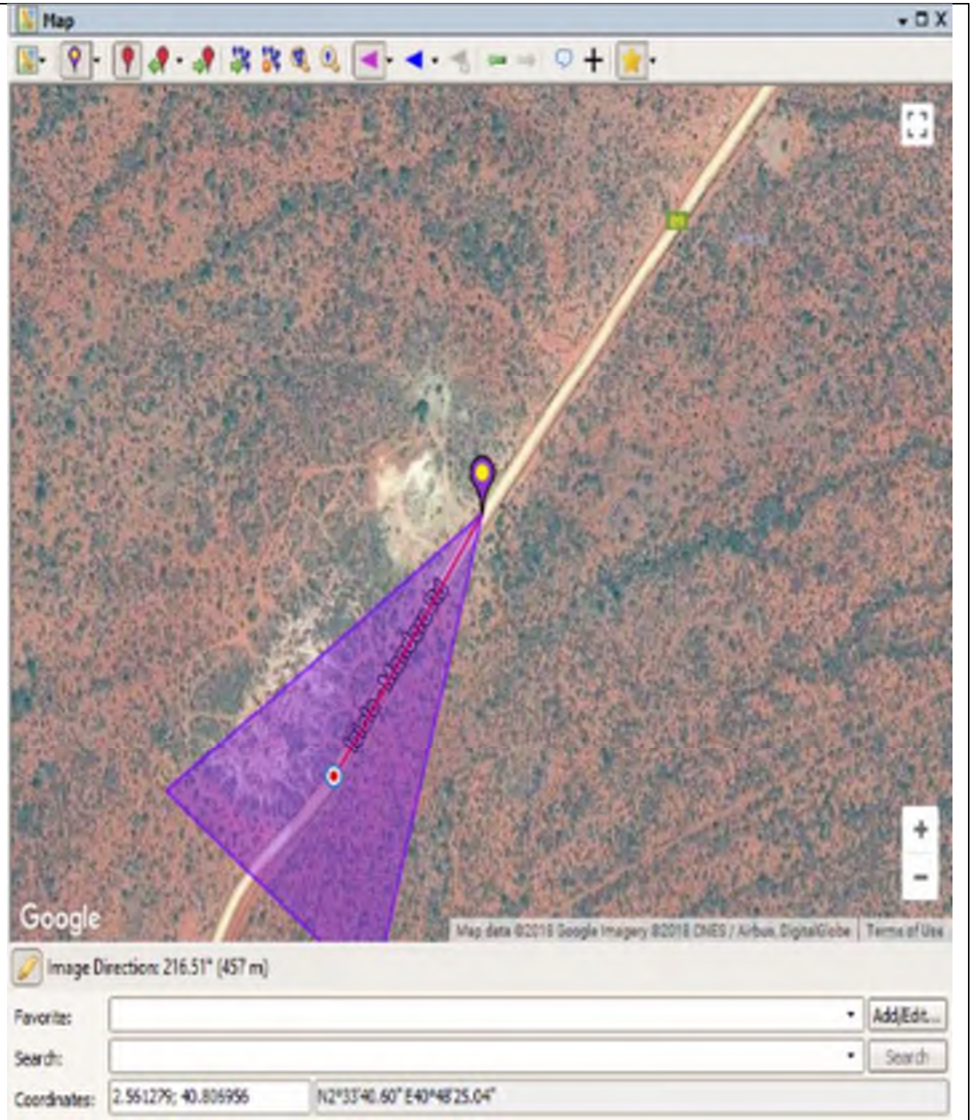


Description: Backward view of approach to culvert section 900 diameter.

Coordinates: N2°33'40.60" E40°48'25.04"

Altitude: 386m

Point 64

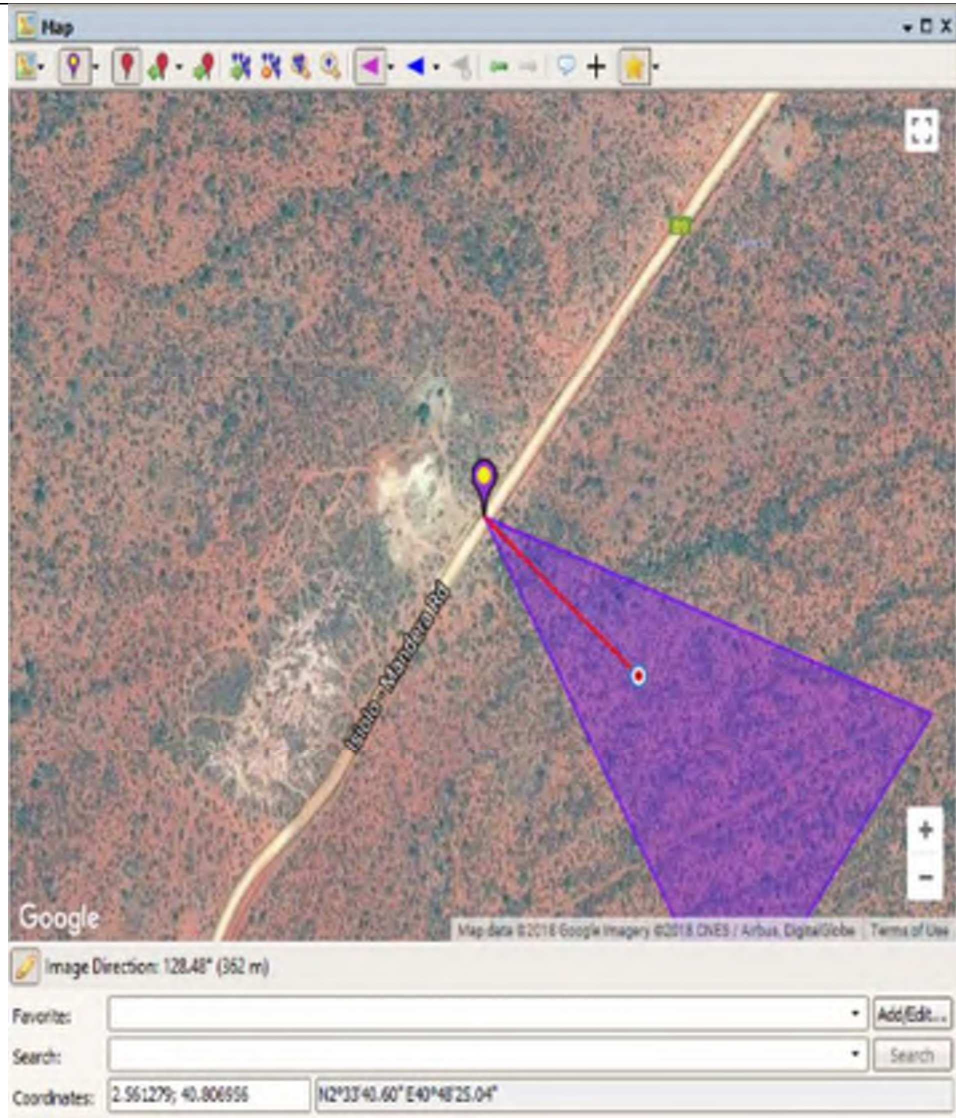


Description: culvert section 900 diameter with no siltation, functioning ok showing the LHS of culvert with photo taken in the right direction

Coordinates: N2°33'40.60" E40°48'25.04"

Altitude: 386m

Point 64

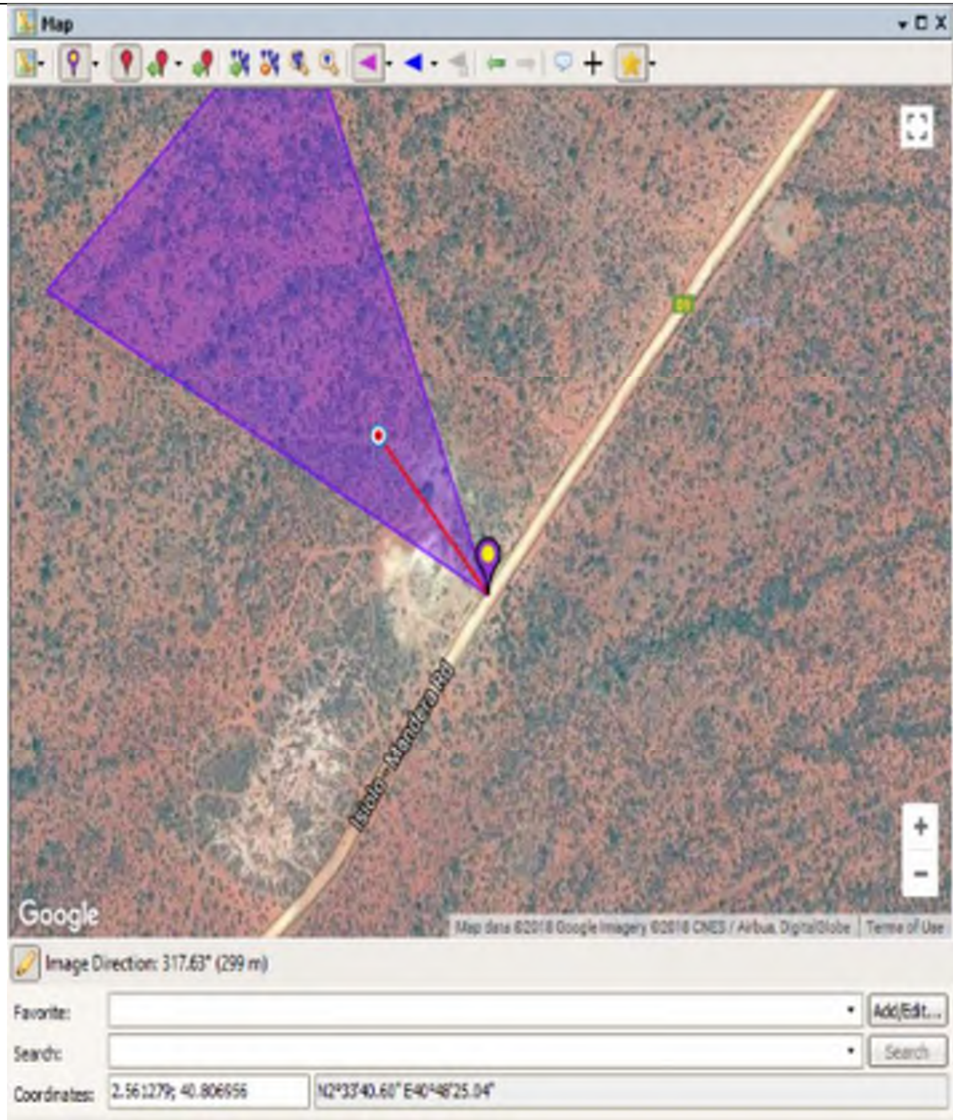


Description: culvert section 900 diameter with no siltation, functioning ok showing the RHS of culvert with photo taken in the left direction

Coordinates: N2°33'40.60" E40°48'25.04"

Altitude: 386m

Point 64

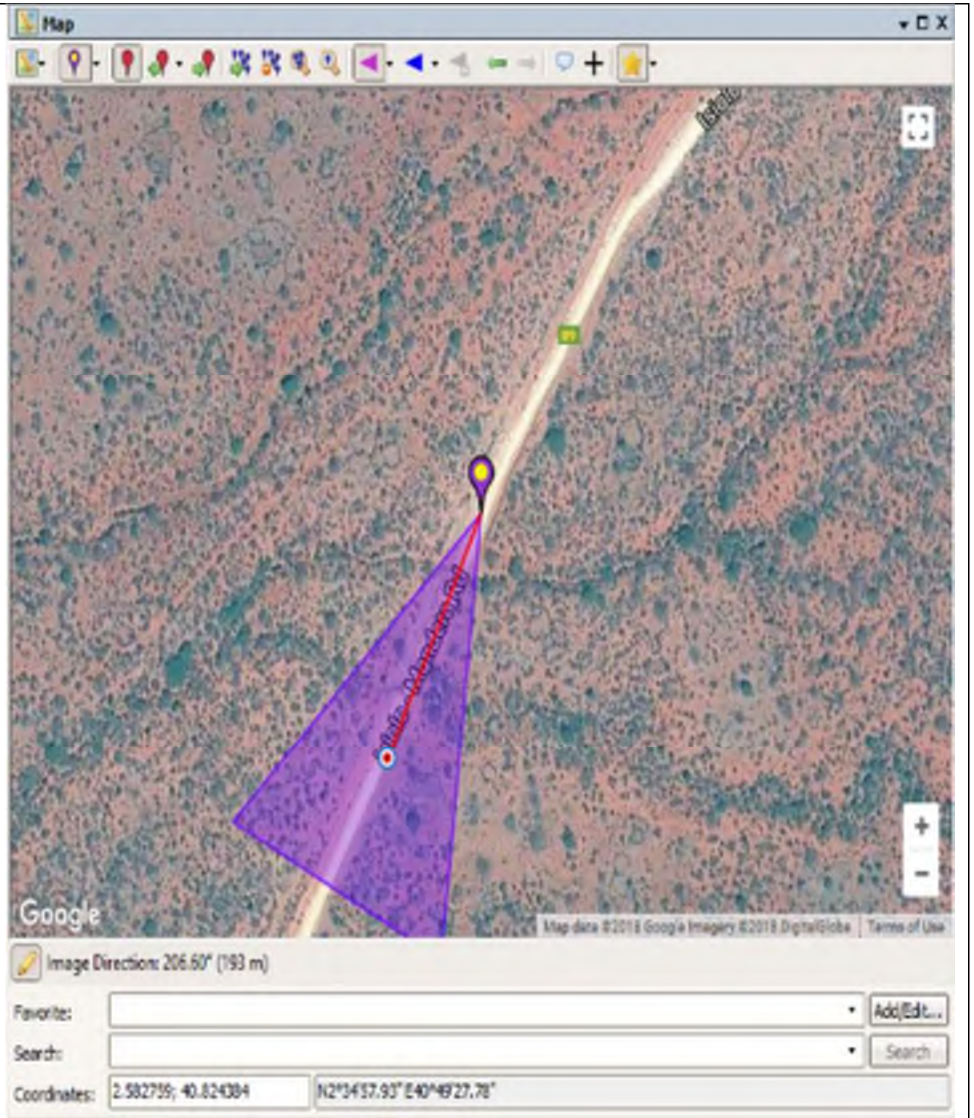


Description: 2 consecutive drifts about 30m apart with lots of fine sand on top and sides of it with photo taken in the backward direction

Coordinates: N2°34'57.93" E40°49'27.78"

Altitude: 387m

Point 65

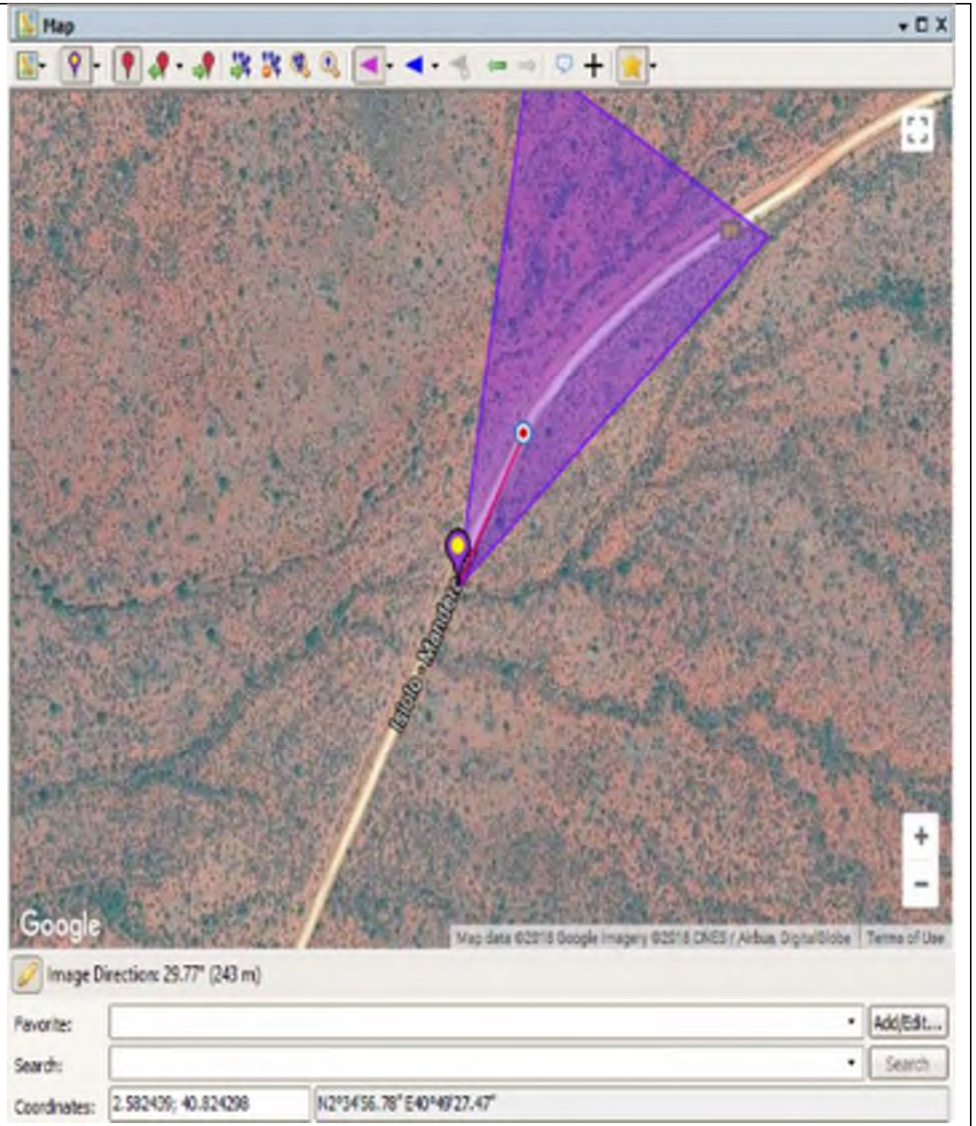


Description: 2 consecutive drifts about 30m apart with lots of fine sand on top and sides of it with photo taken in the forward direction

Coordinates: N2°34'56.78" E40°49'27.47"

Altitude: 393m

Point 65

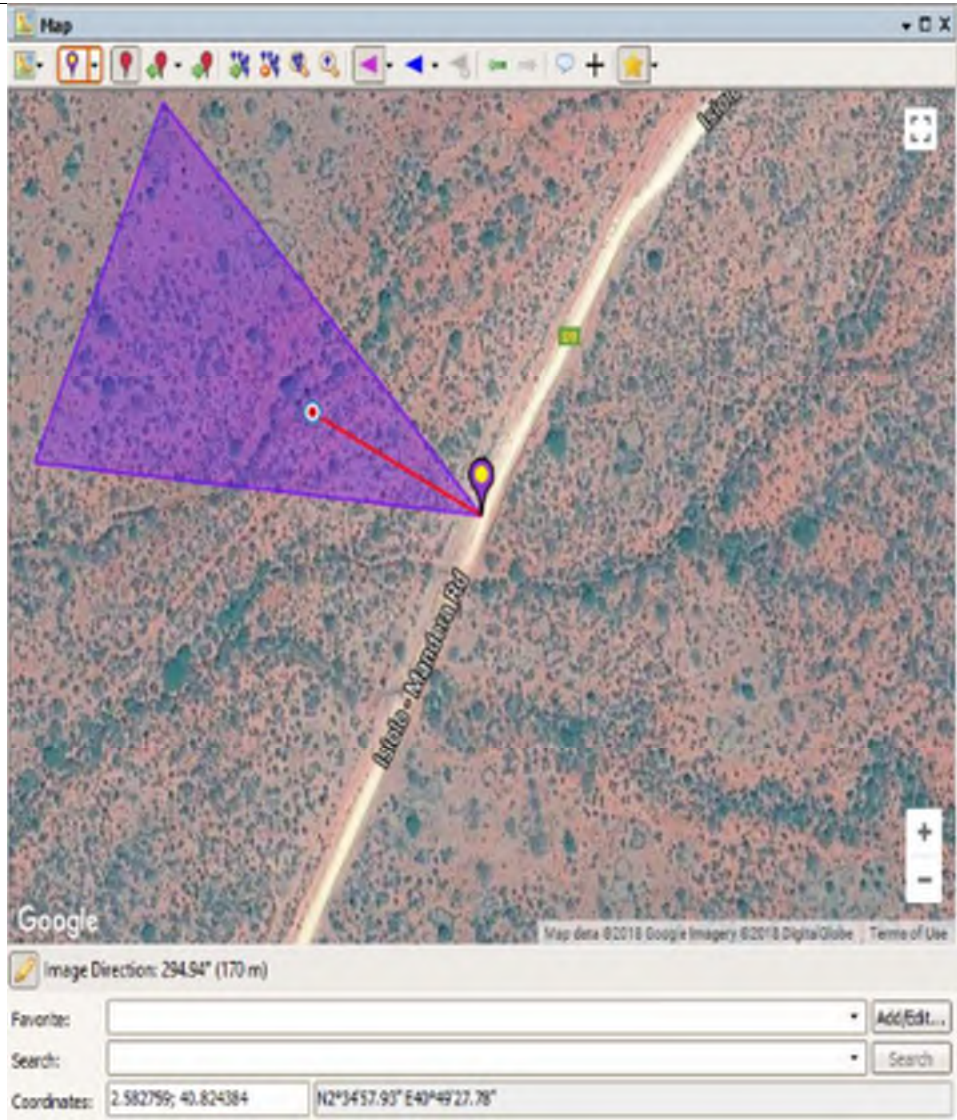


Description: Lhs view of 2 consecutive drifts about 30m apart with lots of fine sand on the downstream.

Coordinates: N2°34'57.93" E40°49'27.78"

Altitude: 387m

Point 65

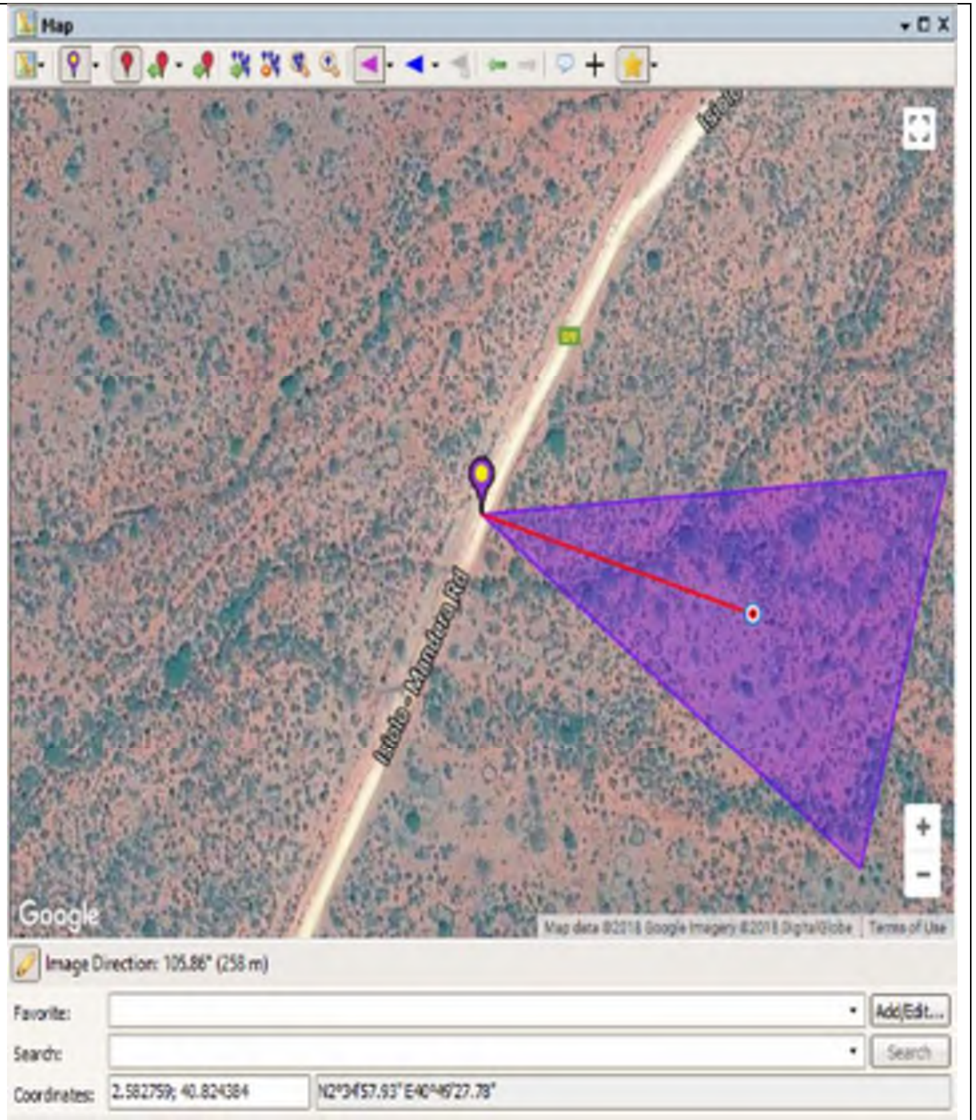


Description: Rhs view of 2 consecutive drifts about 30m apart with lots of fine sand on the upstream

Coordinates: N2°34'57.93" E40°49'27.78"

Altitude: 387m

Point 65

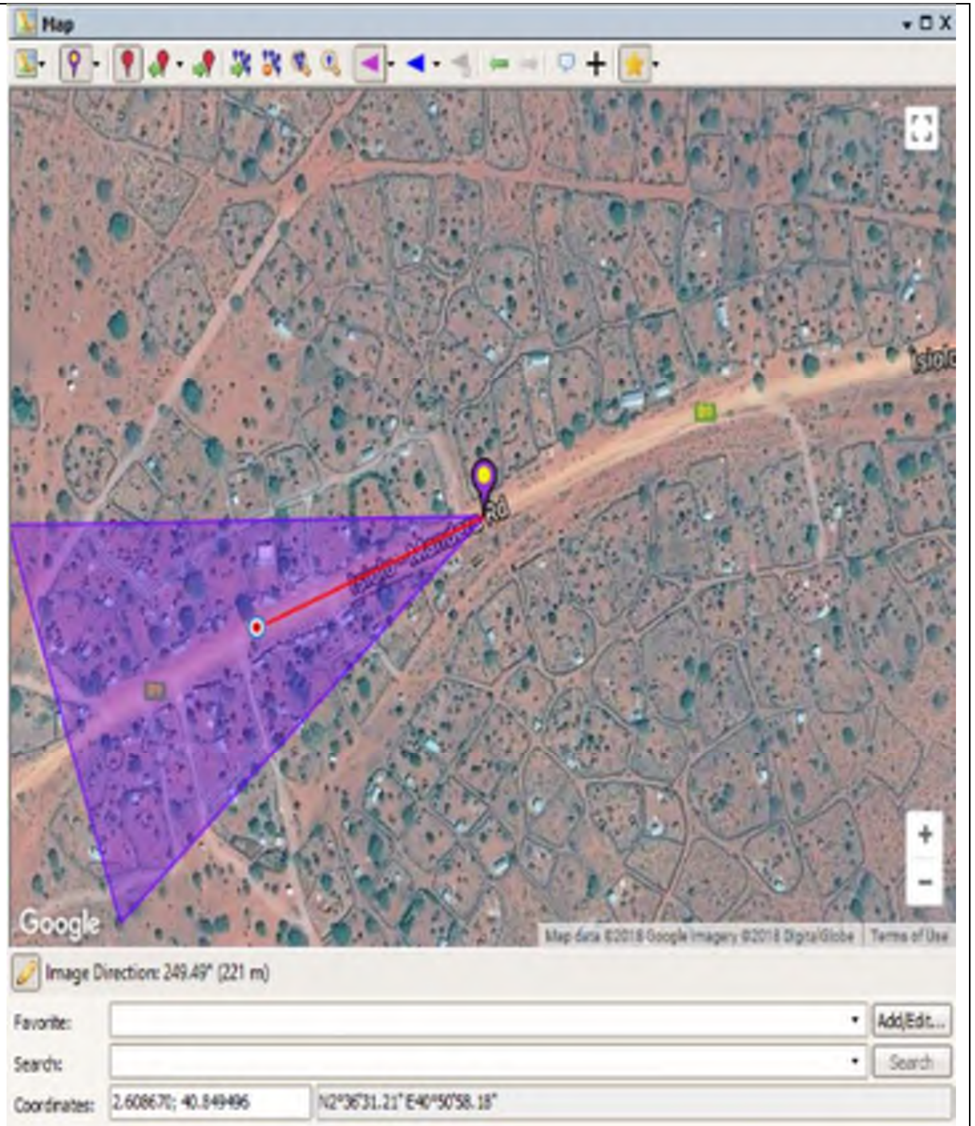


Description: side of road section eroded by flood water , a length of about 500m of the road on both sides with photo taken in the backward direction

Coordinates: N2°36'31.21" E40°50'58.18"

Altitude: 458m

Point 66

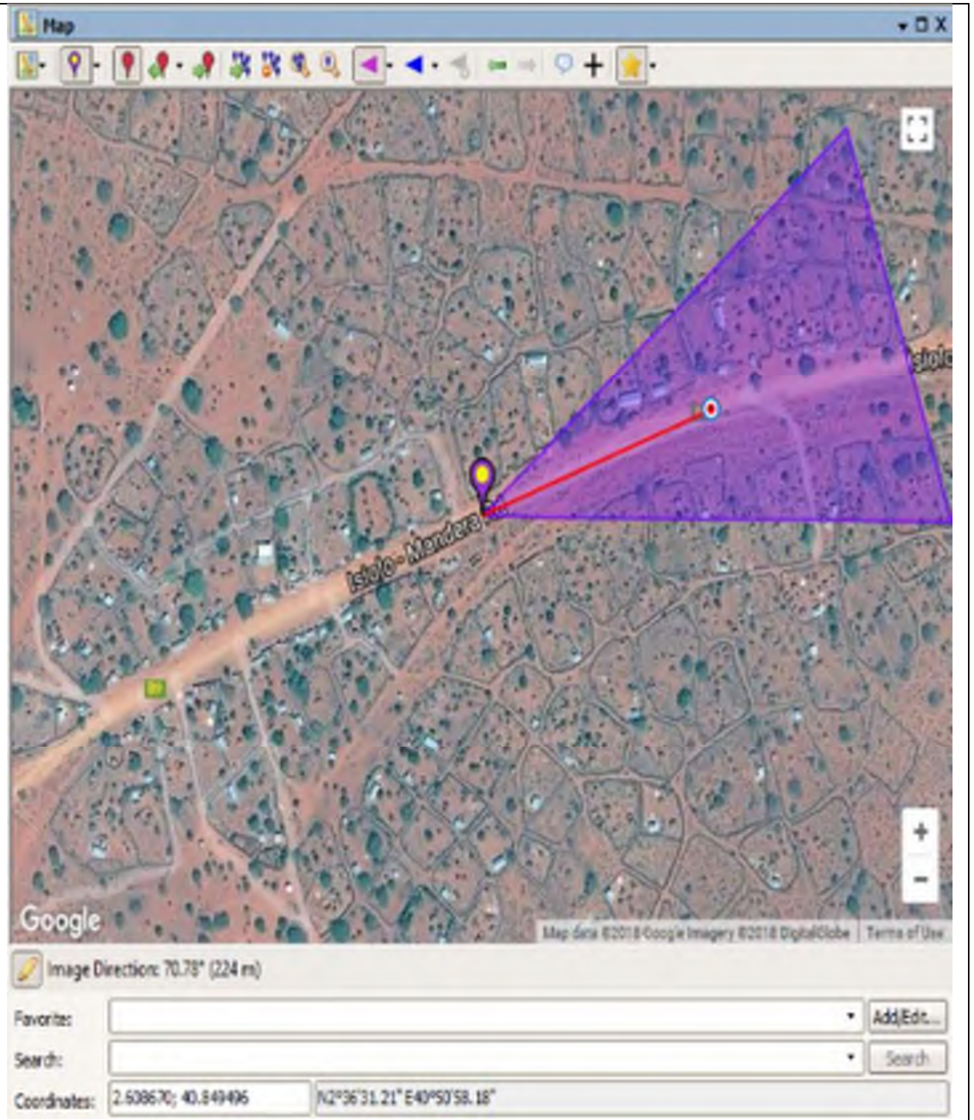


Description: side of road section eroded by flood water , a length of about 500m of the road on both sides with photo taken in the forward direction

Coordinates: N2°36'31.21" E40°50'58.18"

Altitude: 458m

Point 66

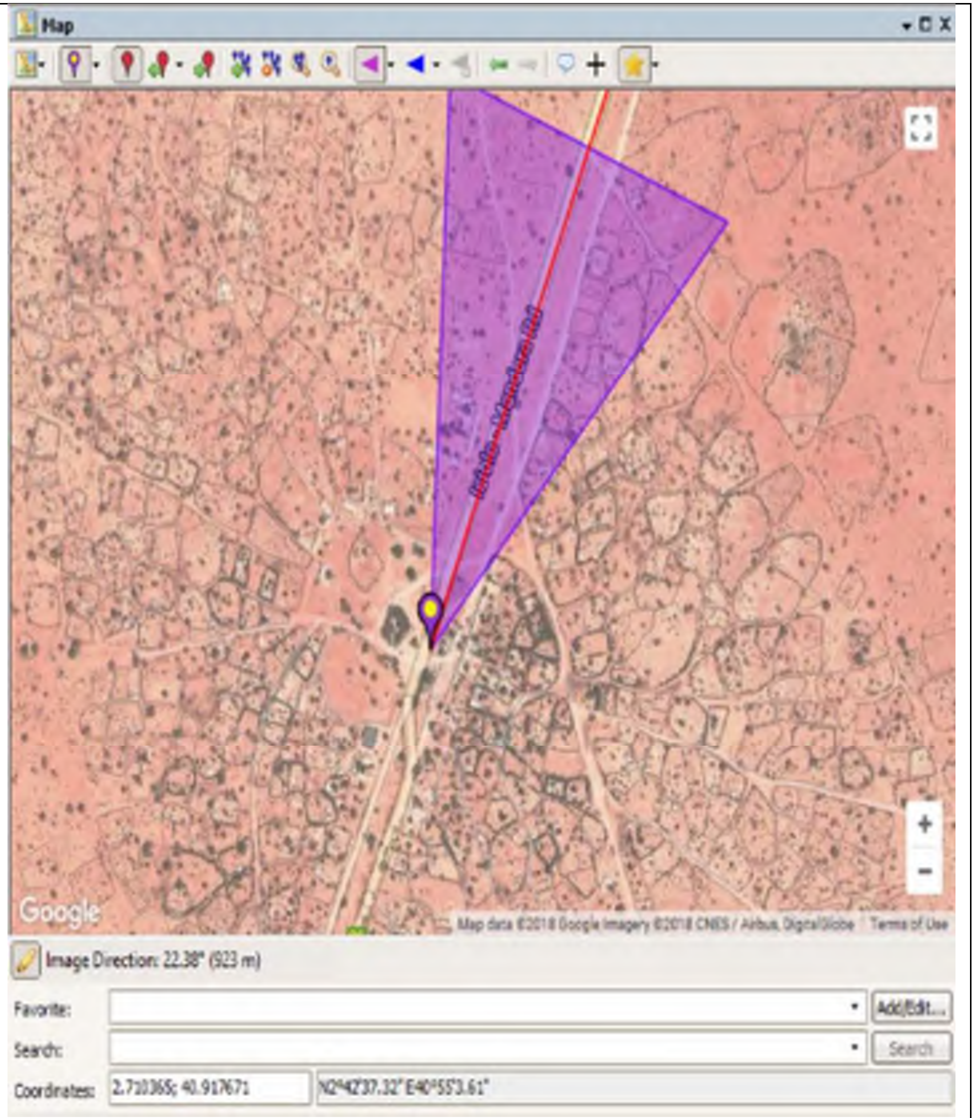


Description: swamp on both sides of the road with photo taken in the forward direction. The area seems to experience flooding in rainy season

Coordinates: N2°42'37.32" E40°55'3.61"

Altitude: 411m

Point 67

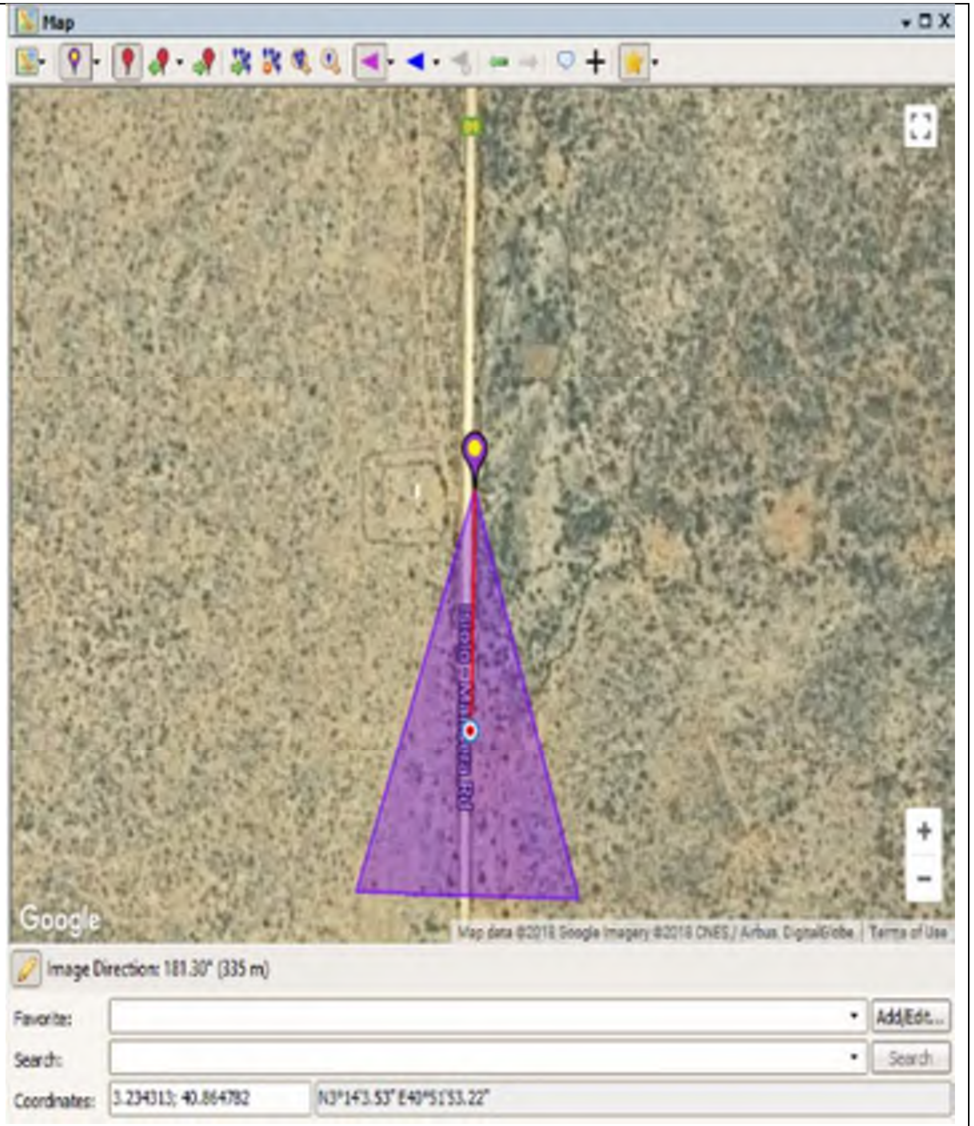


Description: Beginning of tarmacked road section, from Elwak to corner S a section of about 12 km, with both road sides eroded by runoff water with photo taken in the backward direction. The section has no drainage structure

Coordinates: N3°14'3.53" E40°51'53.22"

Altitude: 491m

Point 69

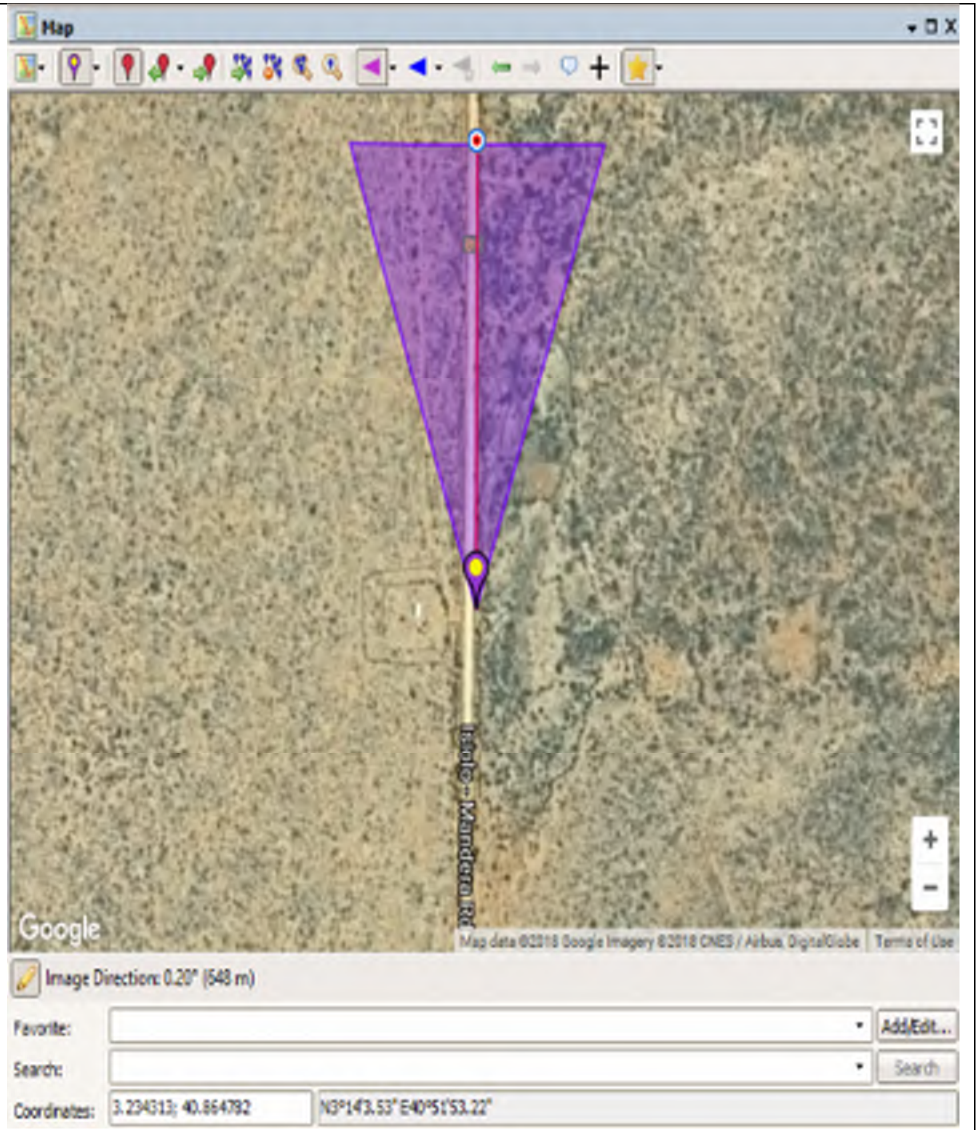


Description: Beginning of tarmacked road section, with both road sides eroded by runoff water with photo taken in the forward direction. The section has no drainage structure

Coordinates: N3°14'3.53" E40°51'53.22"

Altitude: 491m

Point 69

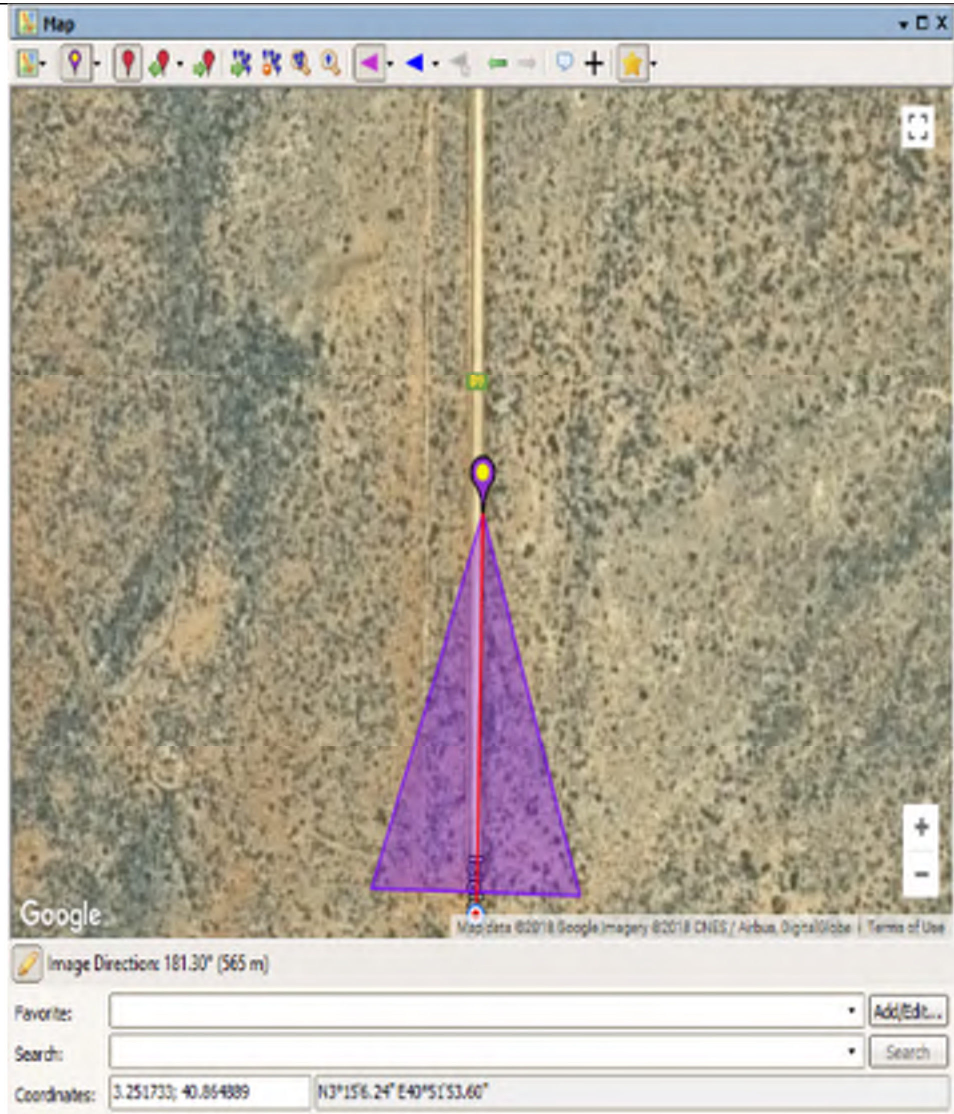


Description: no drainage structure on road section with sides of road having red soil deposits with photo taken in the backward direction

Coordinates: N3°15'6.24" E40°51'53.60"

Altitude: 505m

Point 70

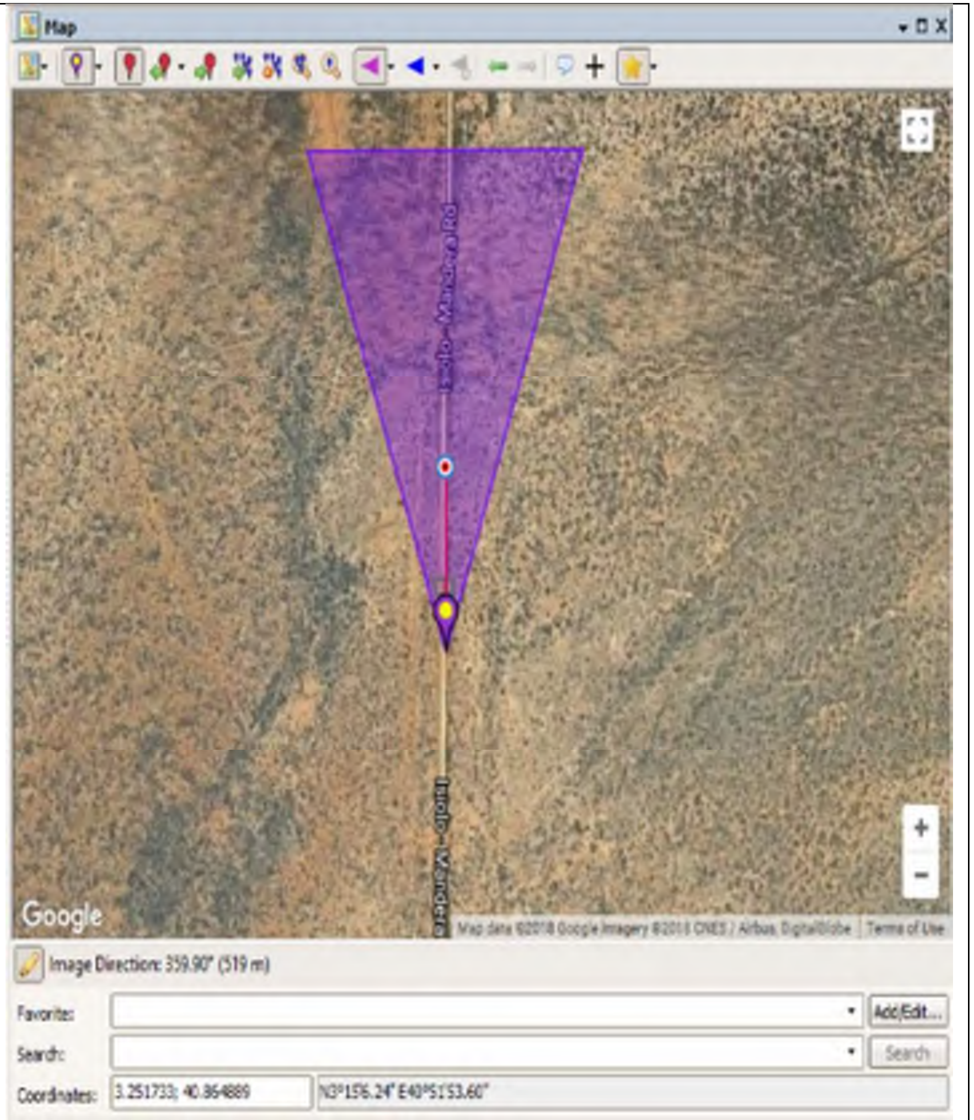


Description: no drainage structure on road section with sides of road having red soil deposits from river flowing with photo taken in the forward direction

Coordinates: N3°15'6.24" E40°51'53.60"

Altitude: 505m

Point 70

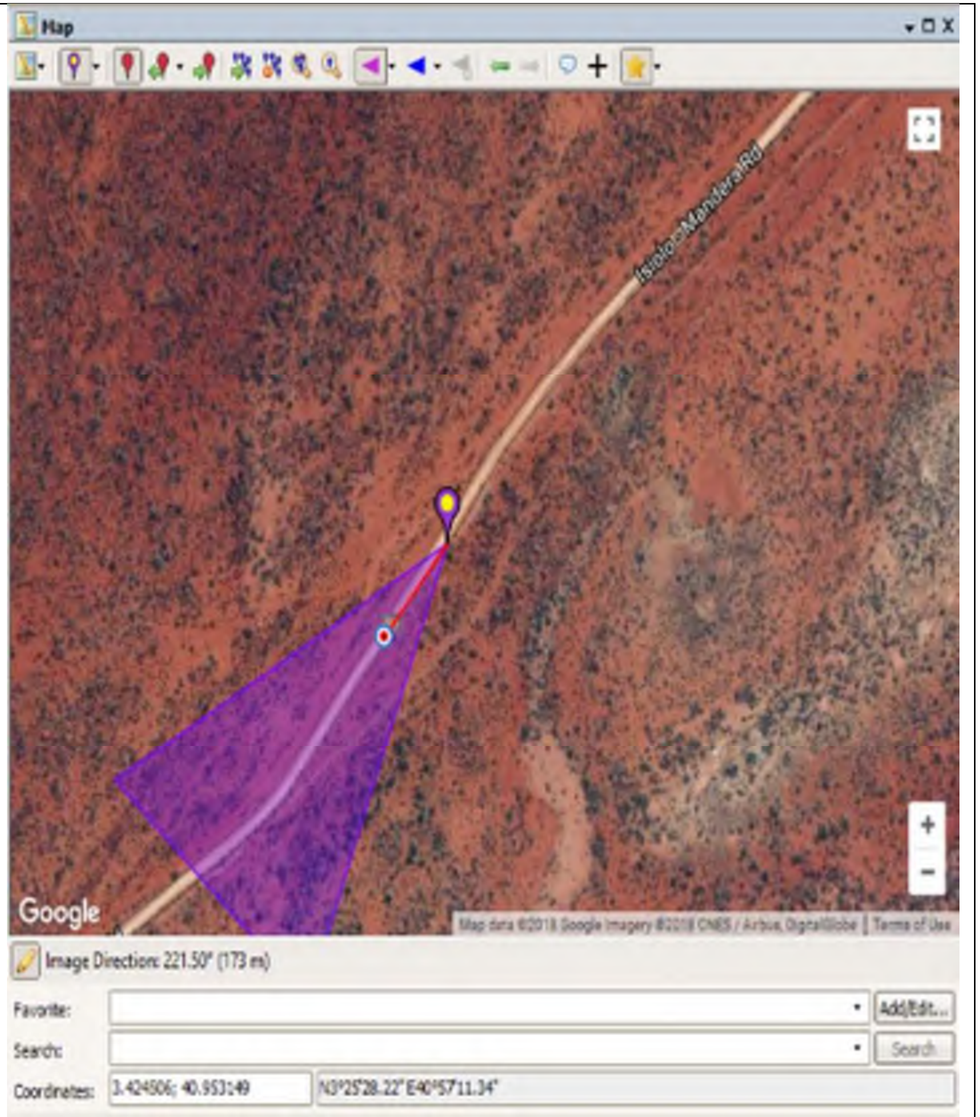


Description: no drainage structure on the section with both sides of road showing gulley erosion by runoff water with photo taken in the backward direction

Coordinates: N3°25'28.22" E40°57'11.34"

Altitude: 598m

Point 72

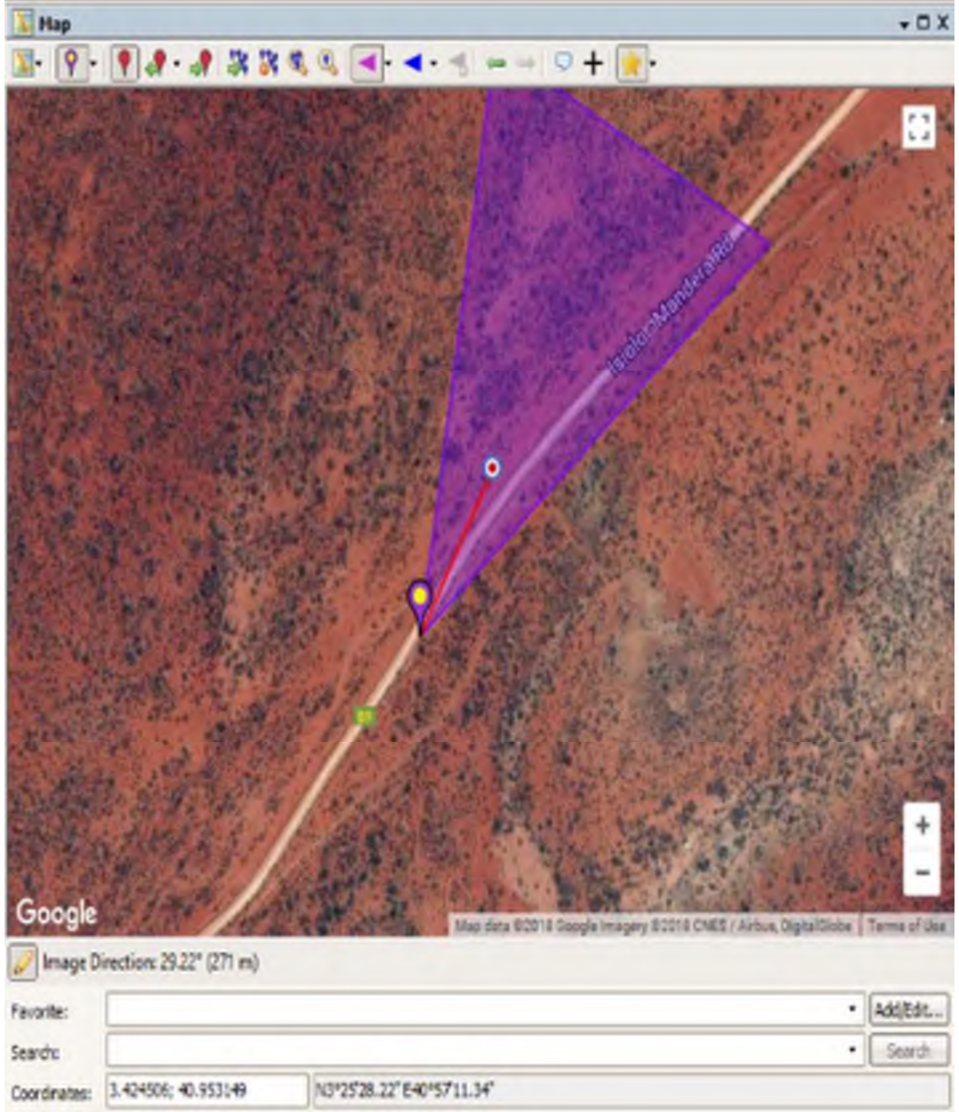


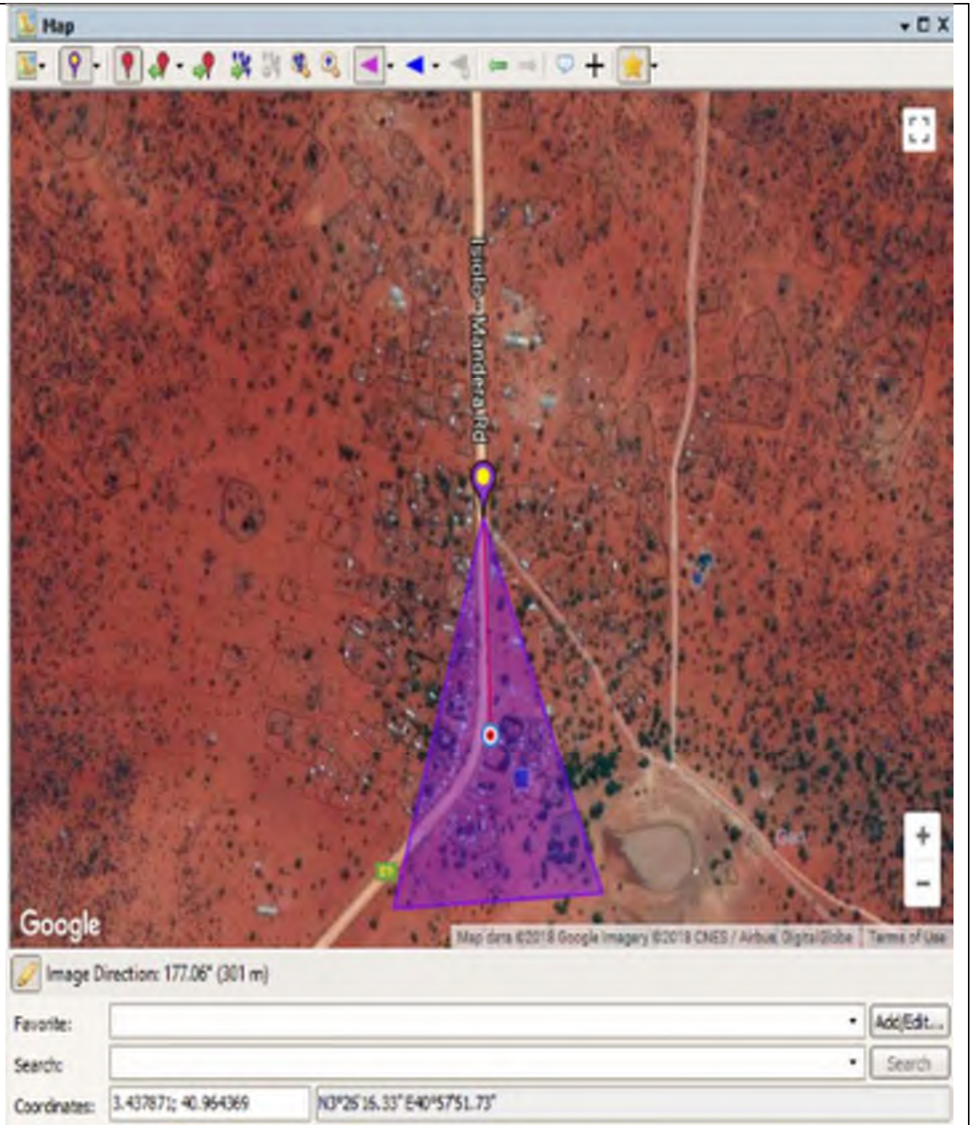
Description: no drainage structure on the section with both sides of road showing gulley erosion by runoff water with photo taken in the forward direction

Coordinates: N3°25'28.22" E40°57'11.34"

Altitude: 598m

Point 72





Description: Backward view of the approach road to a twin pipe culvert 600mm diameter

Coordinates: N3°26'16.33" E40°57'51.73"

Altitude: 579m

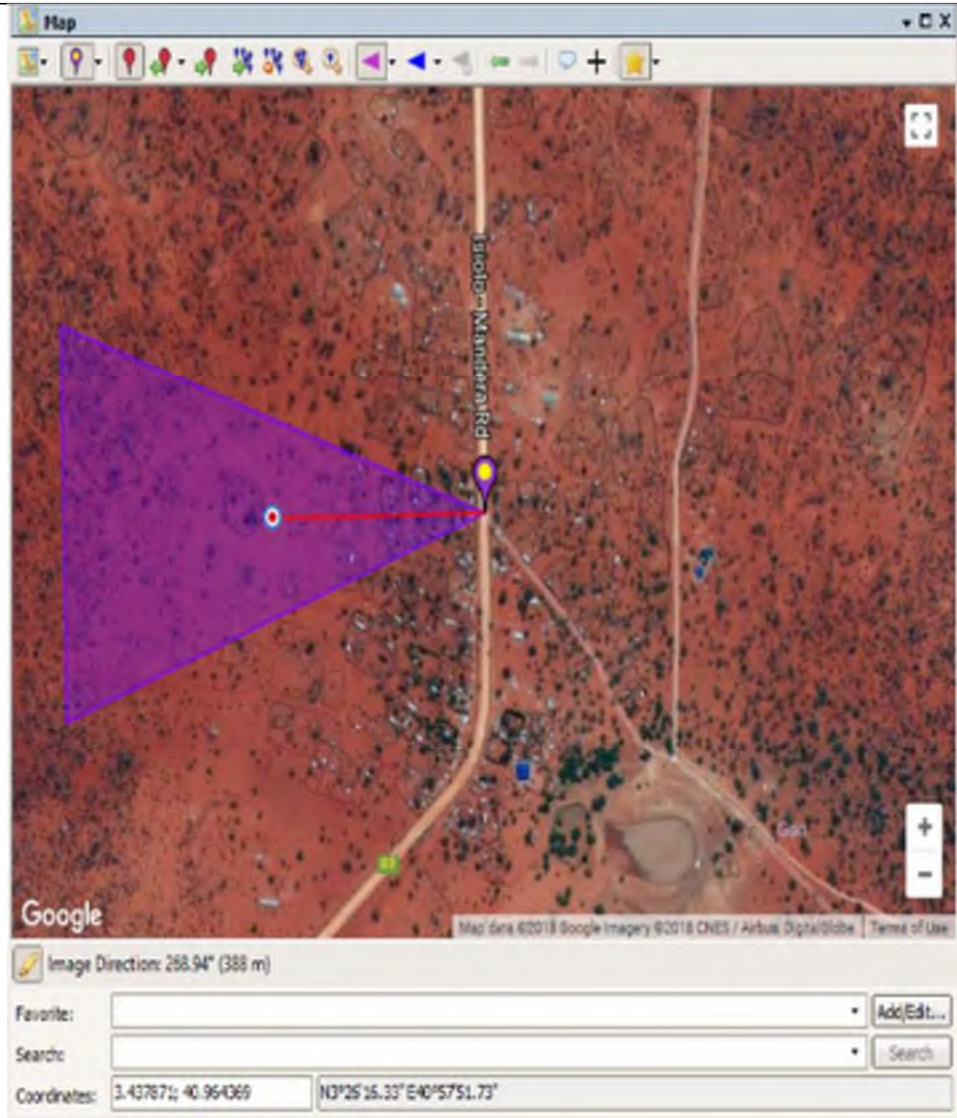
Point 73

Description: Silted twin pipe culvert of 600mm diameter with photo taken in the left direction

Coordinates: N3°26'16.33" E40°57'51.73"

Altitude: 579m

Point 73



Description: Silted twin pipe culvert of 600mm diameter with photo taken in the right side
Coordinates: N3°26'15.83" E40°57'51.23"

Altitude: 579m

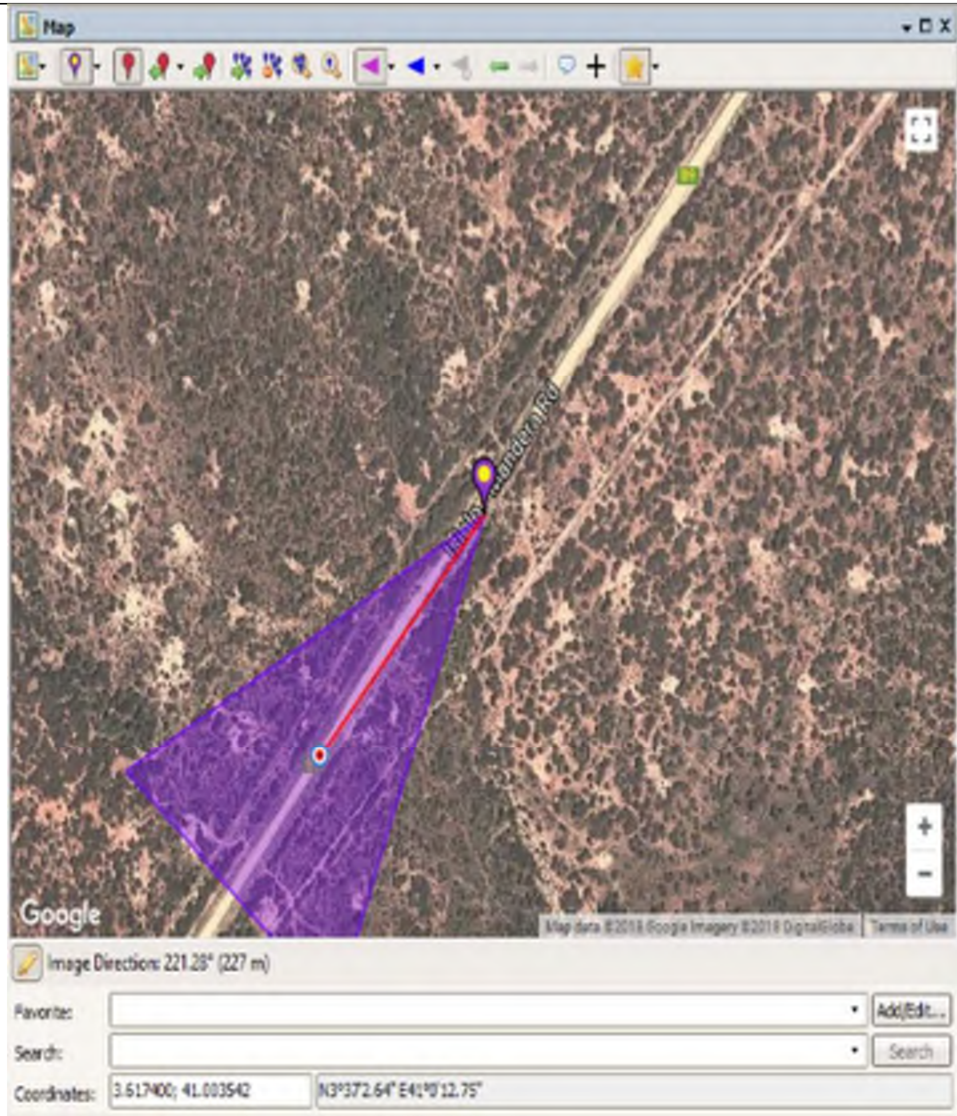
Point 73

Description: Backward view of approach road to a twin pipe culvert section of 600mm diameter. The road section is under construction for upgrading to tarmac road, a project that is funded by the ministry of defence.

Coordinates: N3°37'2.64" E41°0'12.75"

Altitude: 528m

Point 74



Description: Lhs view of a silted twin pipe culvert section of 600mm diameter.

Coordinates: N3°37'2.15" E41°0'11.47"

Altitude: 528m

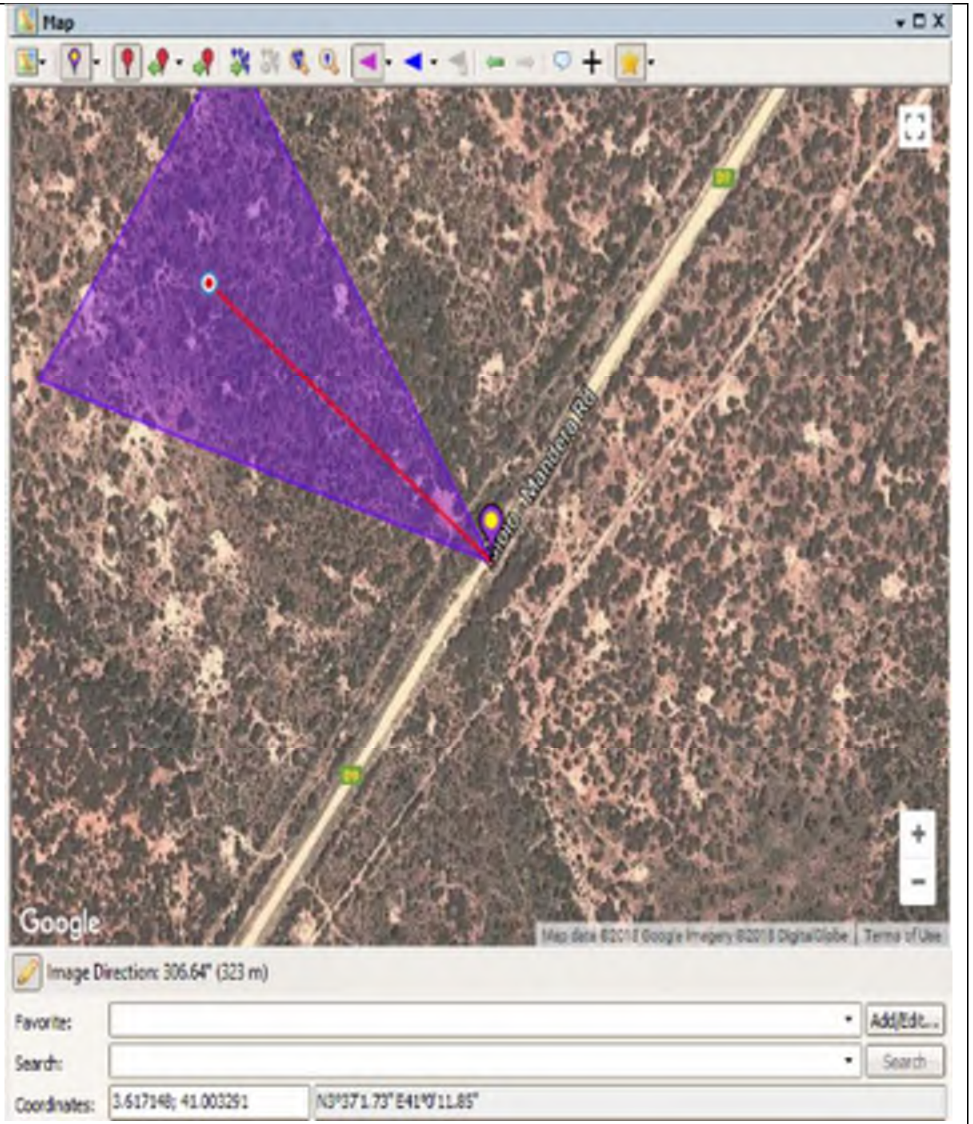
Point 74

Description: Rhs view of a silted twin pipe culvert section of 600mm diameter.

Coordinates: N3°37'1.73" E41°0'11.85"

Altitude: 528m

Point 74

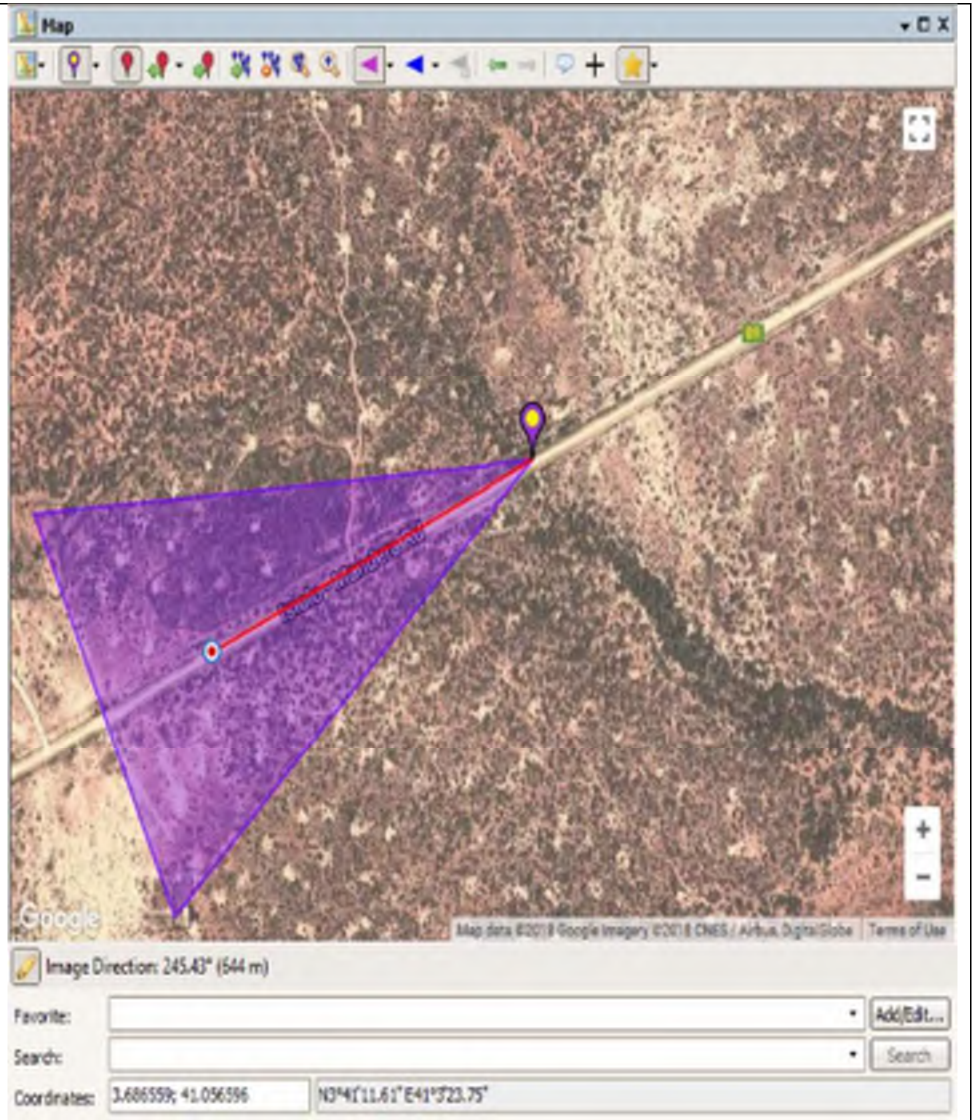


Description: Backward view of the approach road to a 900mm diameter pipe culvert section with no signs of siltation

Coordinates: N3°41'11.61" E41°3'23.75"

Altitude: 480m

Point 76

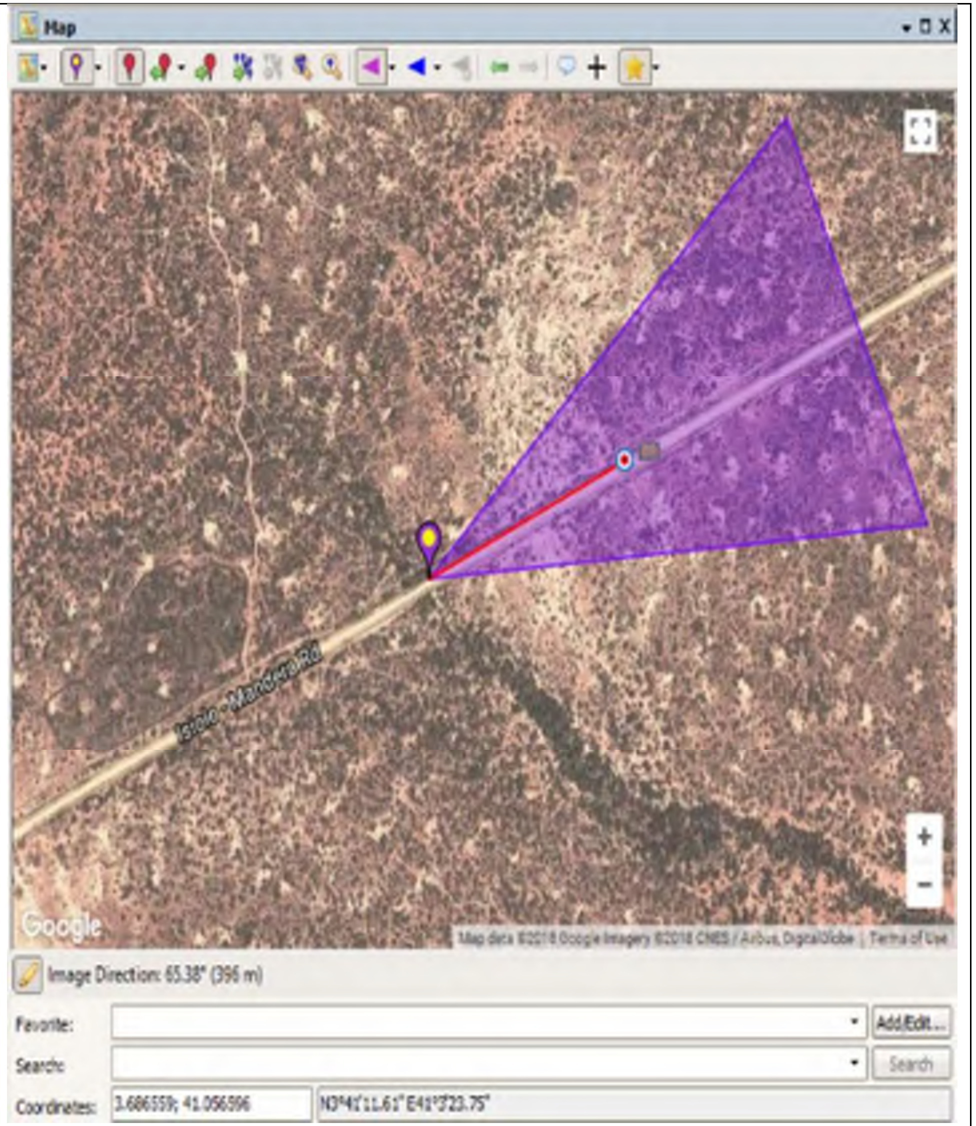


Description: Forward view of the approach road to a 900mm diameter pipe culvert section with no signs of siltation

Coordinates: N3°41'11.61" E41°3'23.75"

Altitude: 480m

Point 76

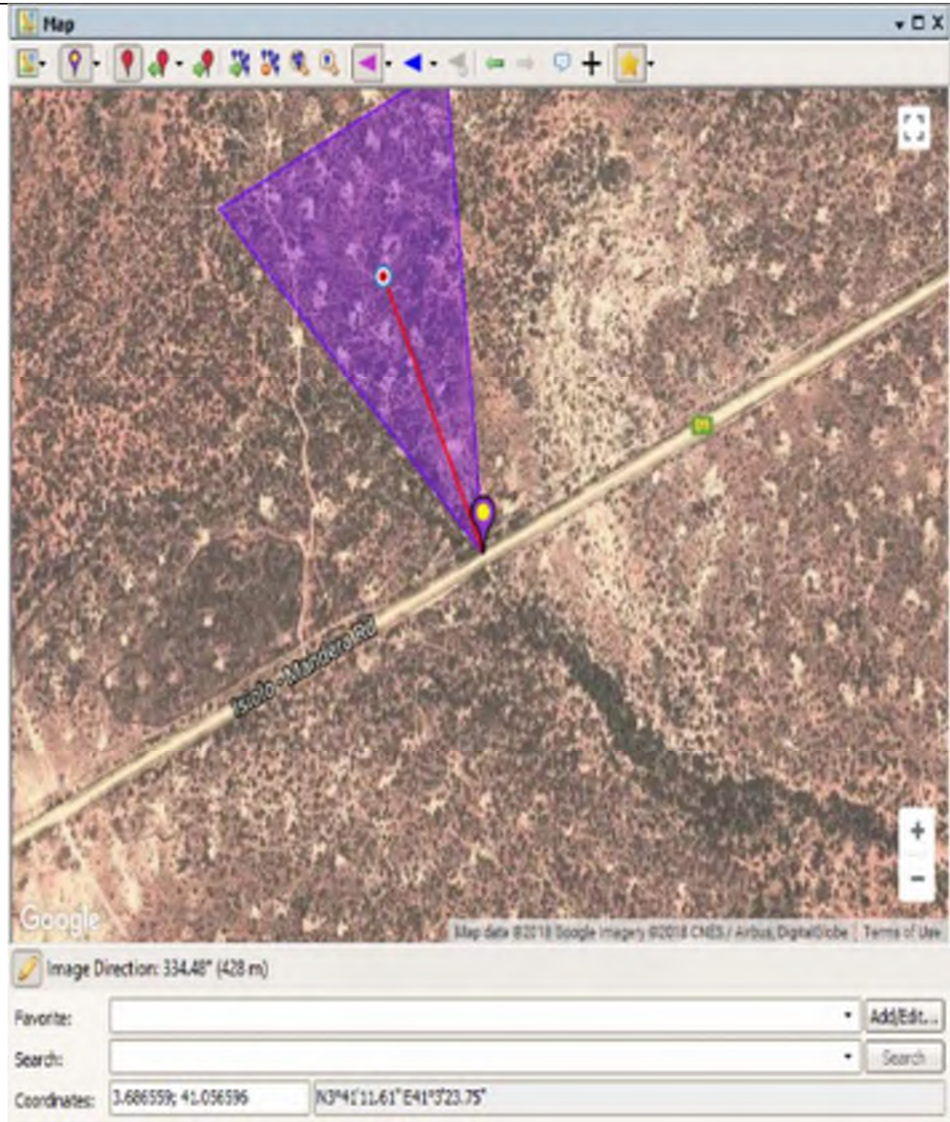


Description: 900mm diameter pipe culvert section with no siltation with photo taken in the left direction

Coordinates: N3°41'11.61" E41°3'23.75"

Altitude: 480m

Point 76

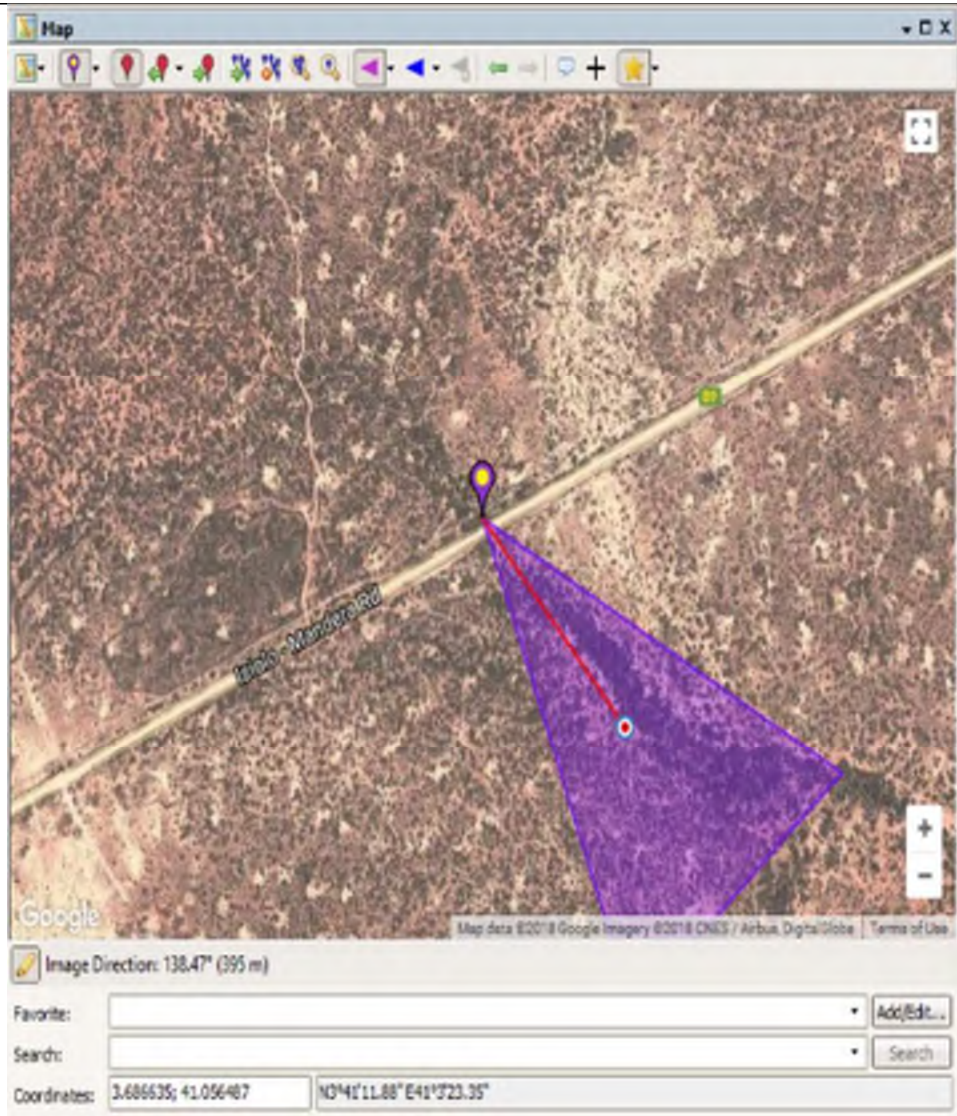


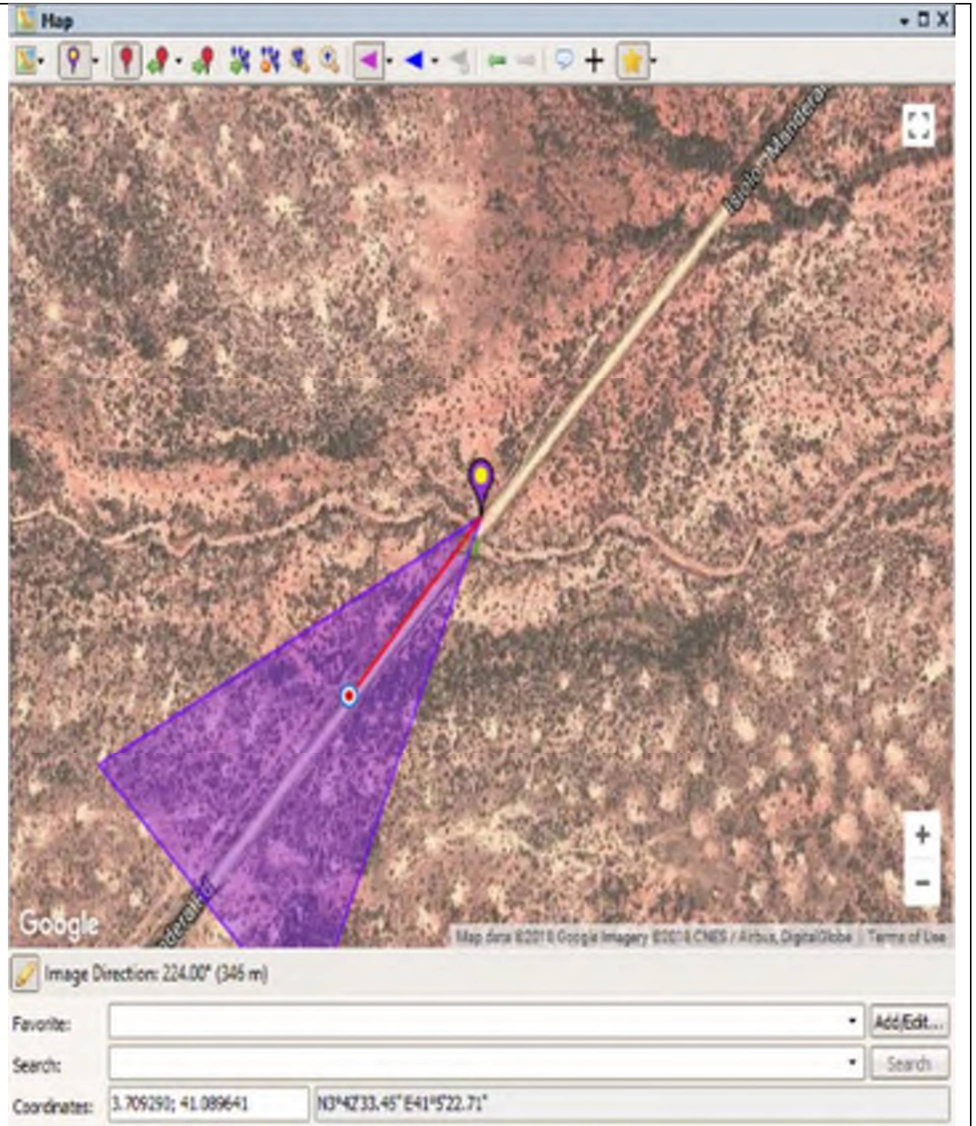
Description: 900mm diameter pipe culvert section with no siltation with photo taken in the right direction

Coordinates: N3°41'11.88" E41°3'23.35"

Altitude: 478m

Point 76





Description: Backward view of the approach roads to triple box culvert section of 6x3m with photo taken in the backward direction

Coordinates: N3°42'33.45" E41°5'22.71"

Altitude: 436m

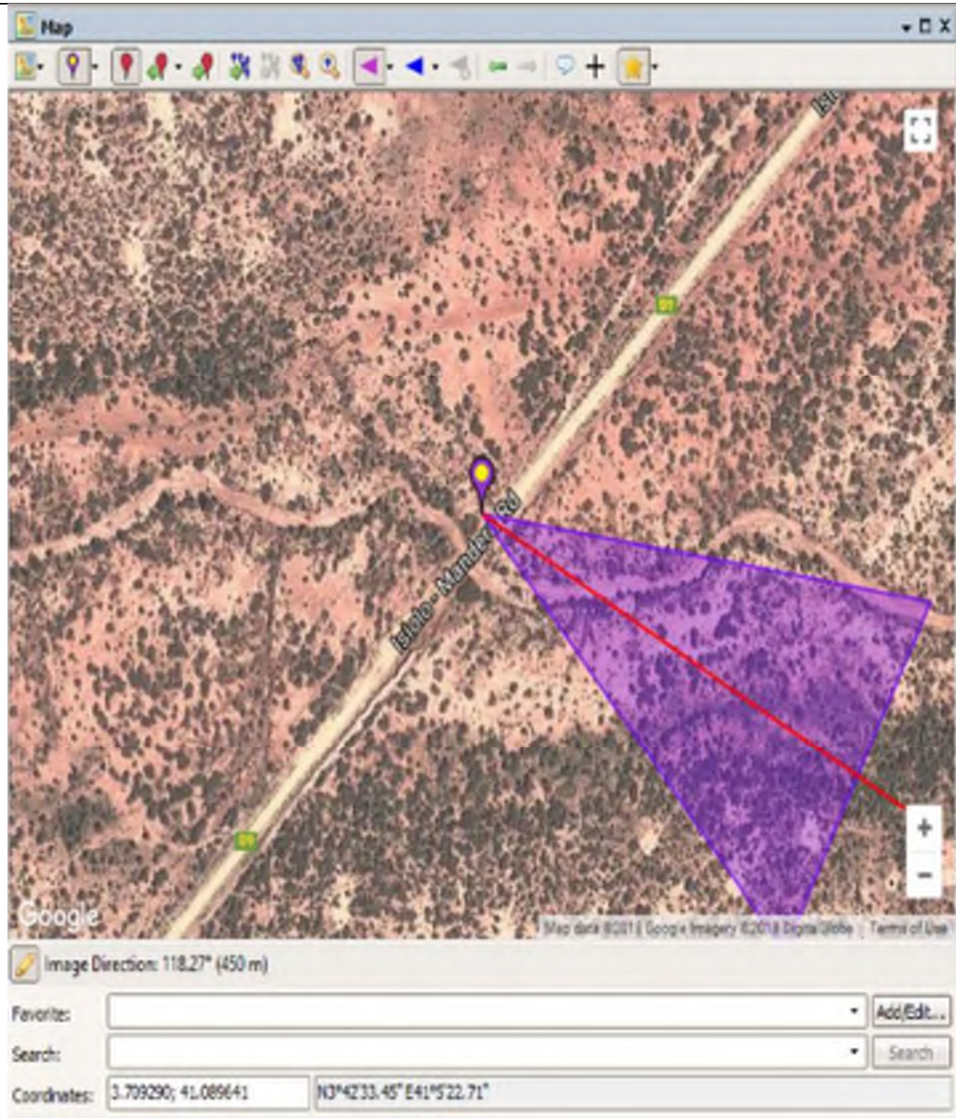
Point 77

Description: triple box culvert section of 6x3m with signs of scouring on the outlet, showing the LHS of culvert with photo taken in the right direction. Scouring is about 1.5m

Coordinates: N3°42'33.45" E41°5'22.71"

Altitude: 436m

Point 77

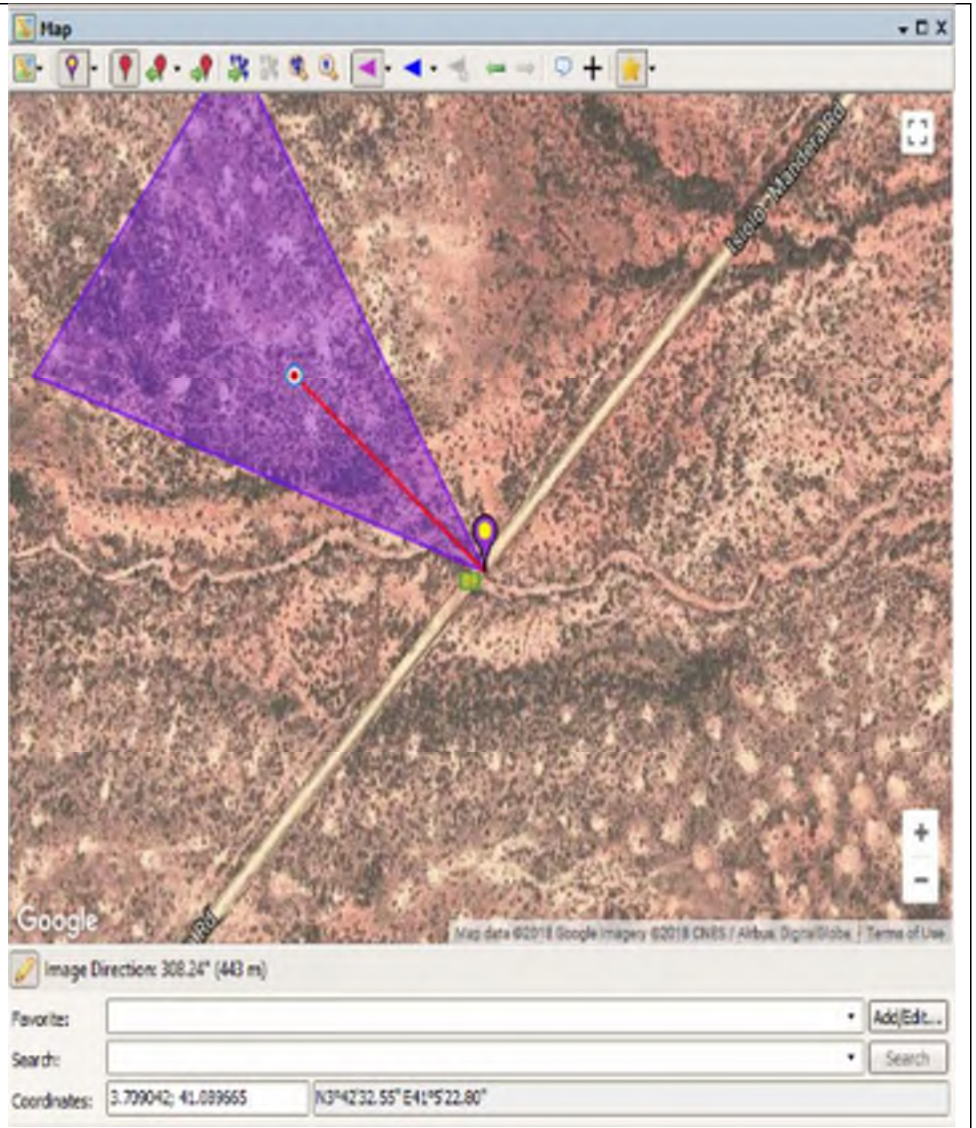


Description: triple box culvert section of 6x3m showing the RHS of culvert with photo taken in the left direction

Coordinates: N3°42'32.55" E41°5'22.80"

Altitude: 436m

Point 77



Description: Forward view of the approach roads to a twin culvert section of diameter 600mm with no siltation

Coordinates: N3°54'34.29" E41°13'16.61"

Altitude: 292m

Point 79

Description: Lhs view of the approach roads to a twin culvert section of diameter 600mm with no siltation

Coordinates: N3°54'34.51" E41°13'16.07"

Altitude: 292m

Point 79

Description: Rhs view of the approach roads to a twin culvert section of diameter 600mm with no siltation

Coordinates: N3°54'34.51" E41°13'16.07"

Altitude: 292m

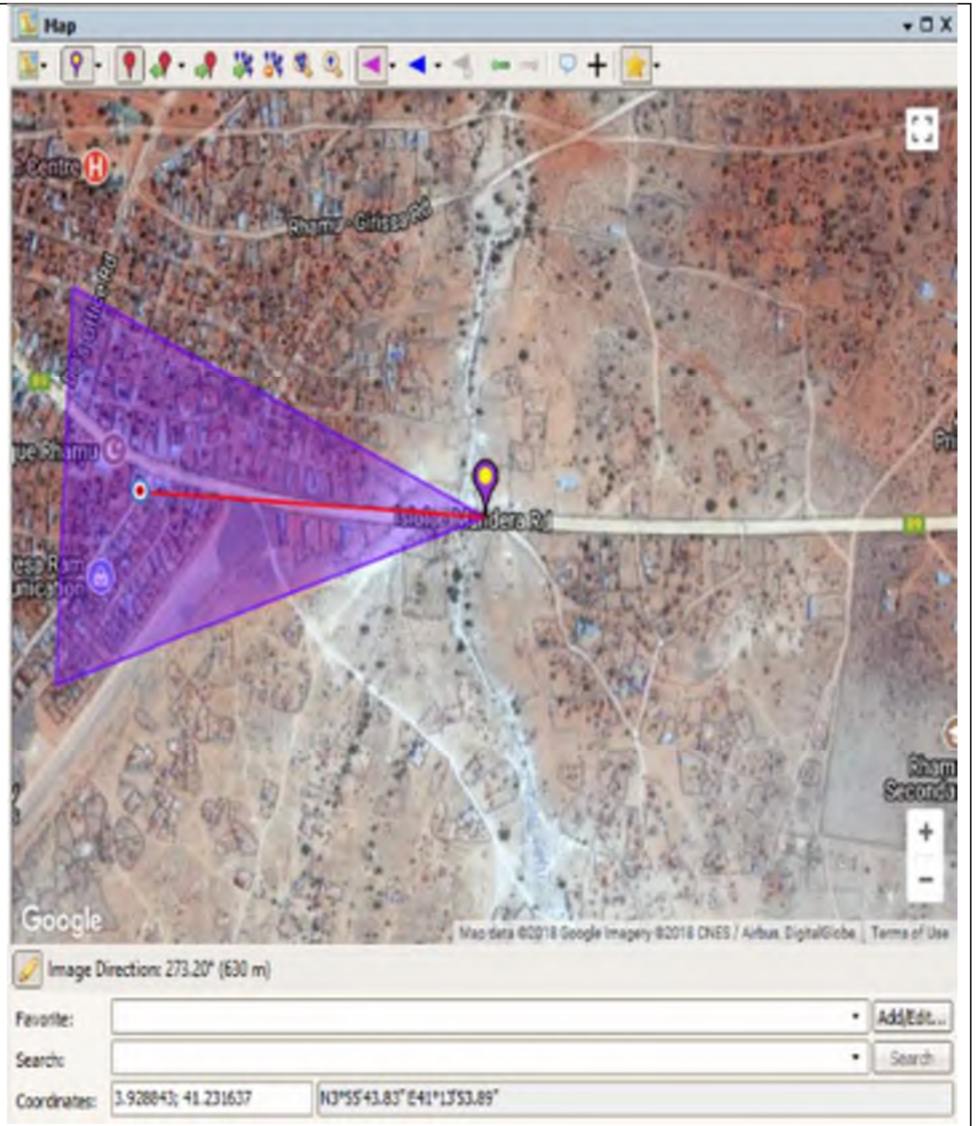
Point 79

Description: Backward view of the approach roads to twin pipe culverts of diameter 1200mm.

Coordinates: N3°55'43.83" E41°13'53.89"

Altitude: 259m

Point 80

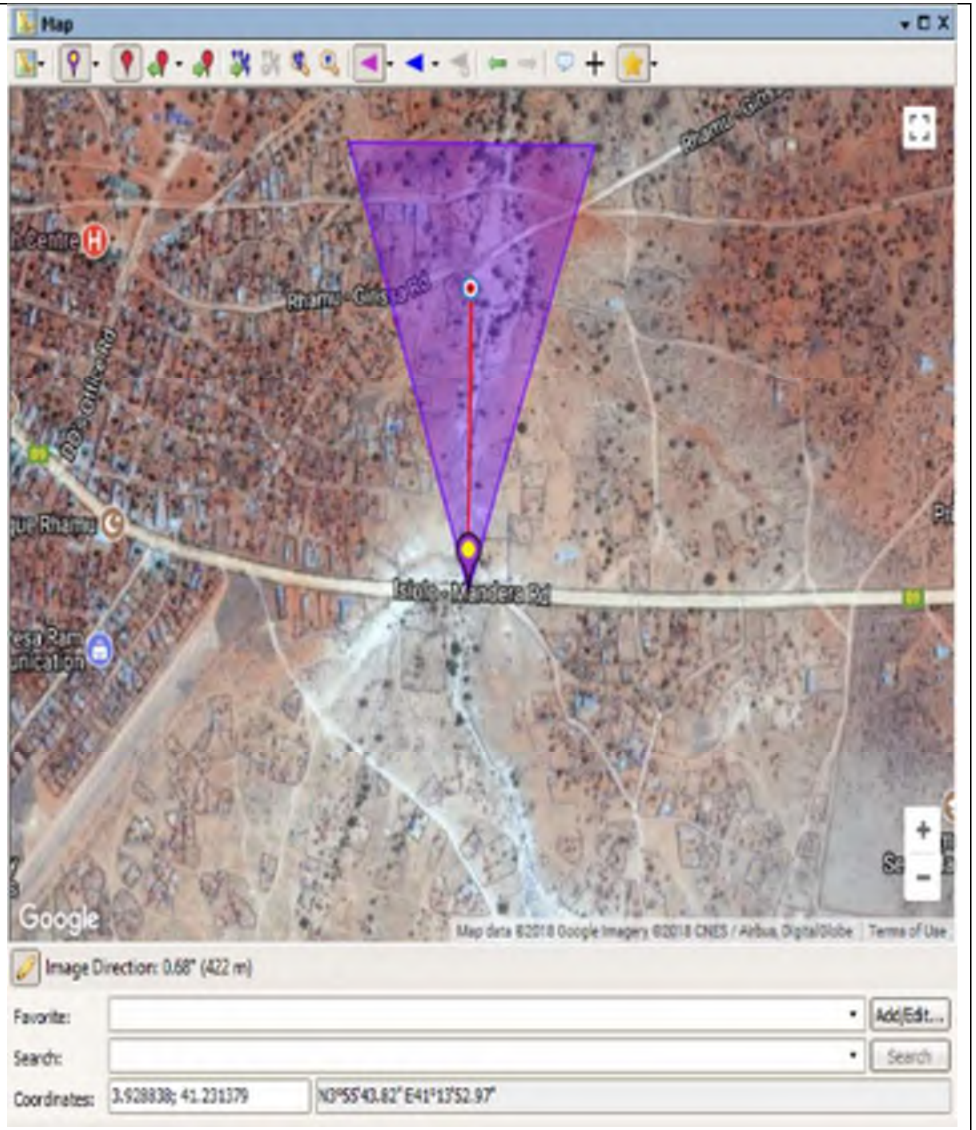


Description: Rhs view of the twin pipe culverts of diameter 1200mm, showing signs of siltation.

Coordinates: N3°55'43.82" E41°13'52.97"

Altitude: 259m

Point 80



Description: Lhs view of the twin pipe culverts of diameter 1200mm. The gabion walls have been eroded on the left side. Dry riverbed with sand on both sides of the riverbed with photo showing the LHS of culvert and taken in the right direction

Coordinates: N3°55'43.95" E41°13'53.01"

Altitude: 259m

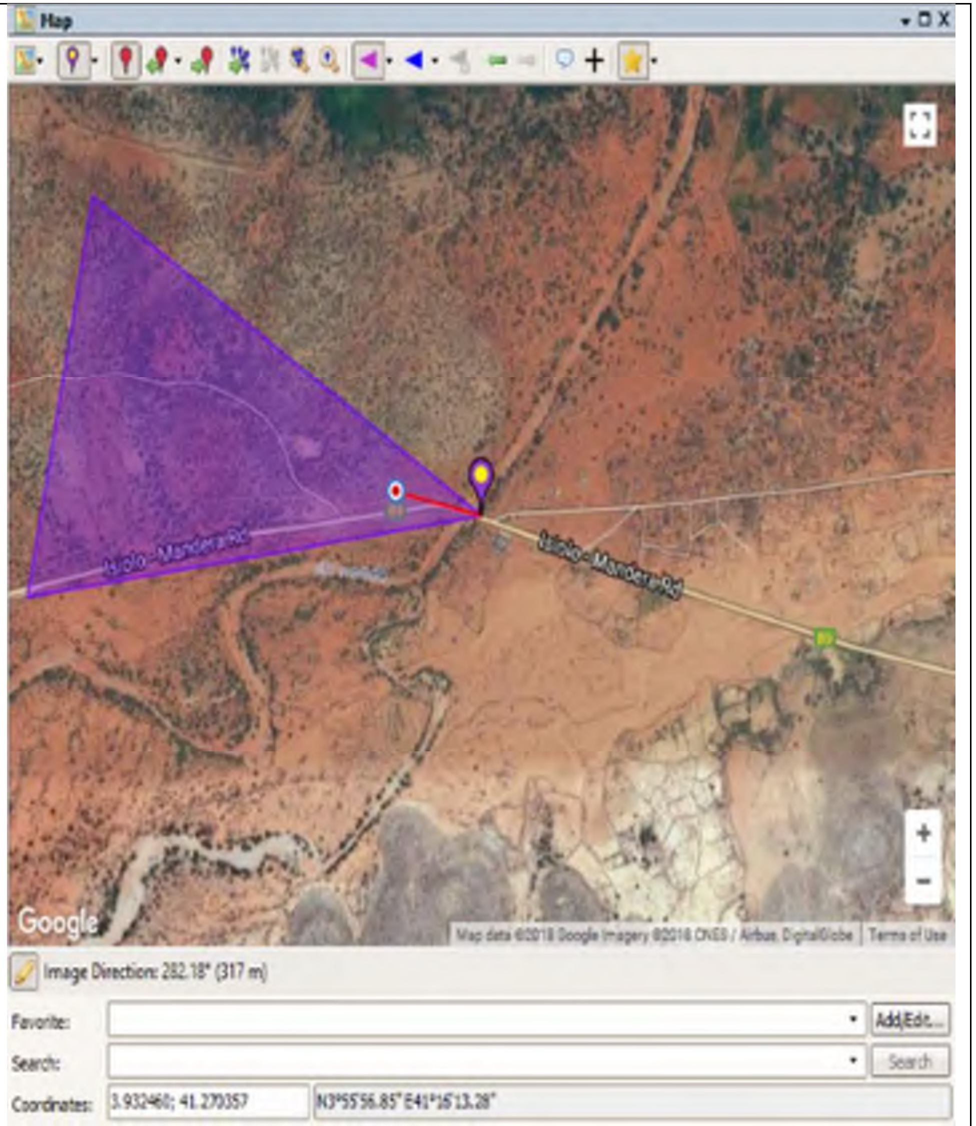
Point 80

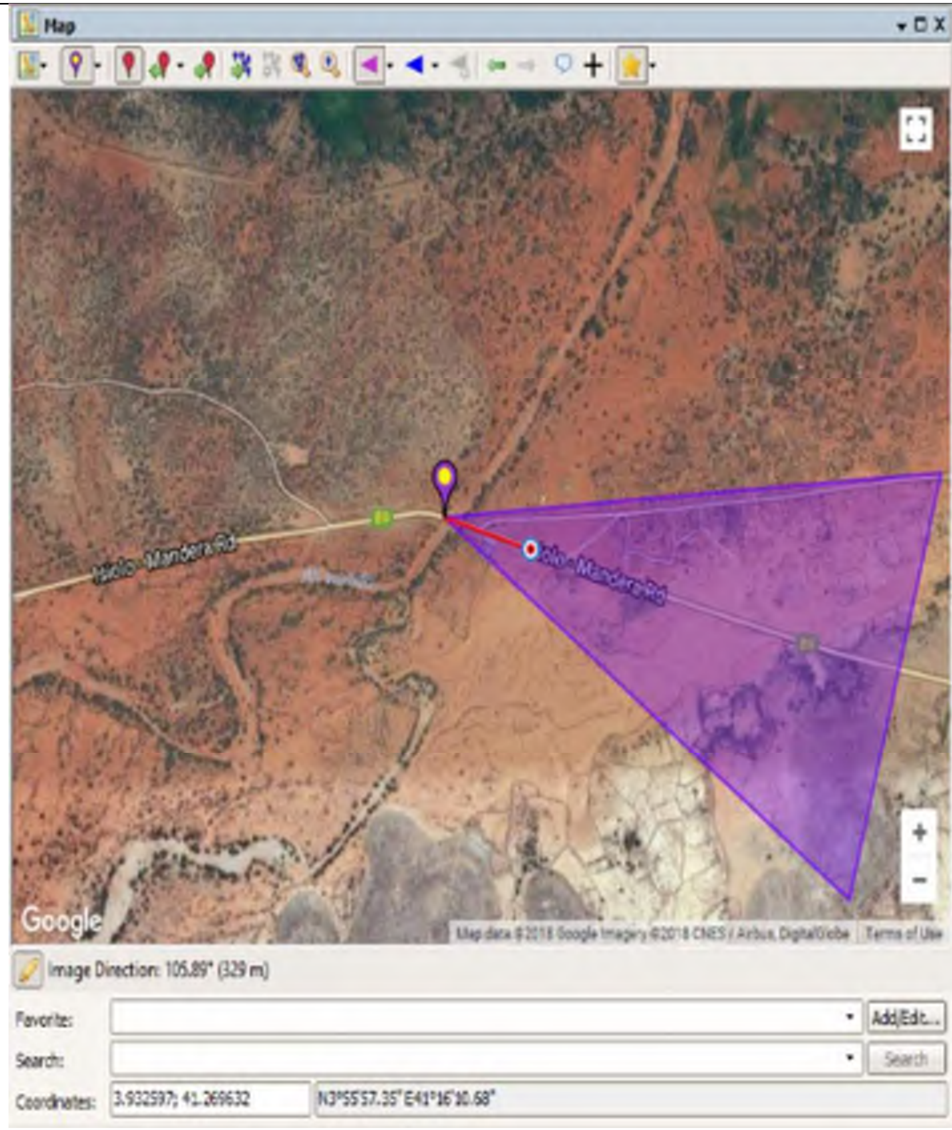
Description: dry river bed crossing of Ali Wando river (seasonal) f about 40m wide with no drainage structure, there is presence of sand and boulders on riverbed with photo taken in the backward direction

Coordinates: N3°55'56.85" E41°16'13.28"

Altitude: 227m

Point 81





Description: dry river bed crossing of Ali Wando river (seasonal) f about 40m wide with no drainage structure, there is presence of sand and boulders on riverbed with photo taken in the forward direction

Coordinates: N3°55'57.35" E41°16'10.68"

Altitude: 248m

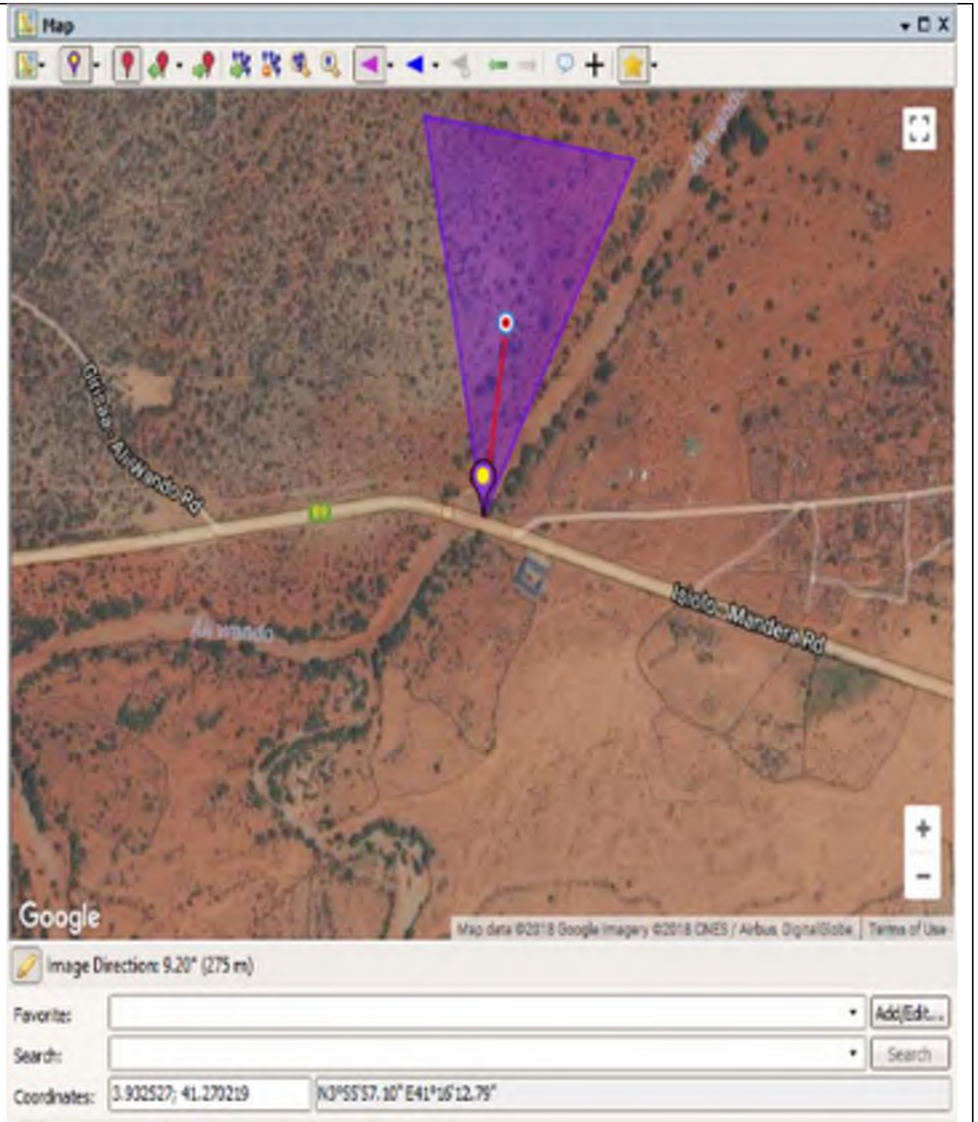
Point 81

Description: Lhs view of the sandy river bed crossing of Ali Wando river

Coordinates: N3°55'57.10" E41°16'12.79"

Altitude: 233m

Point 81

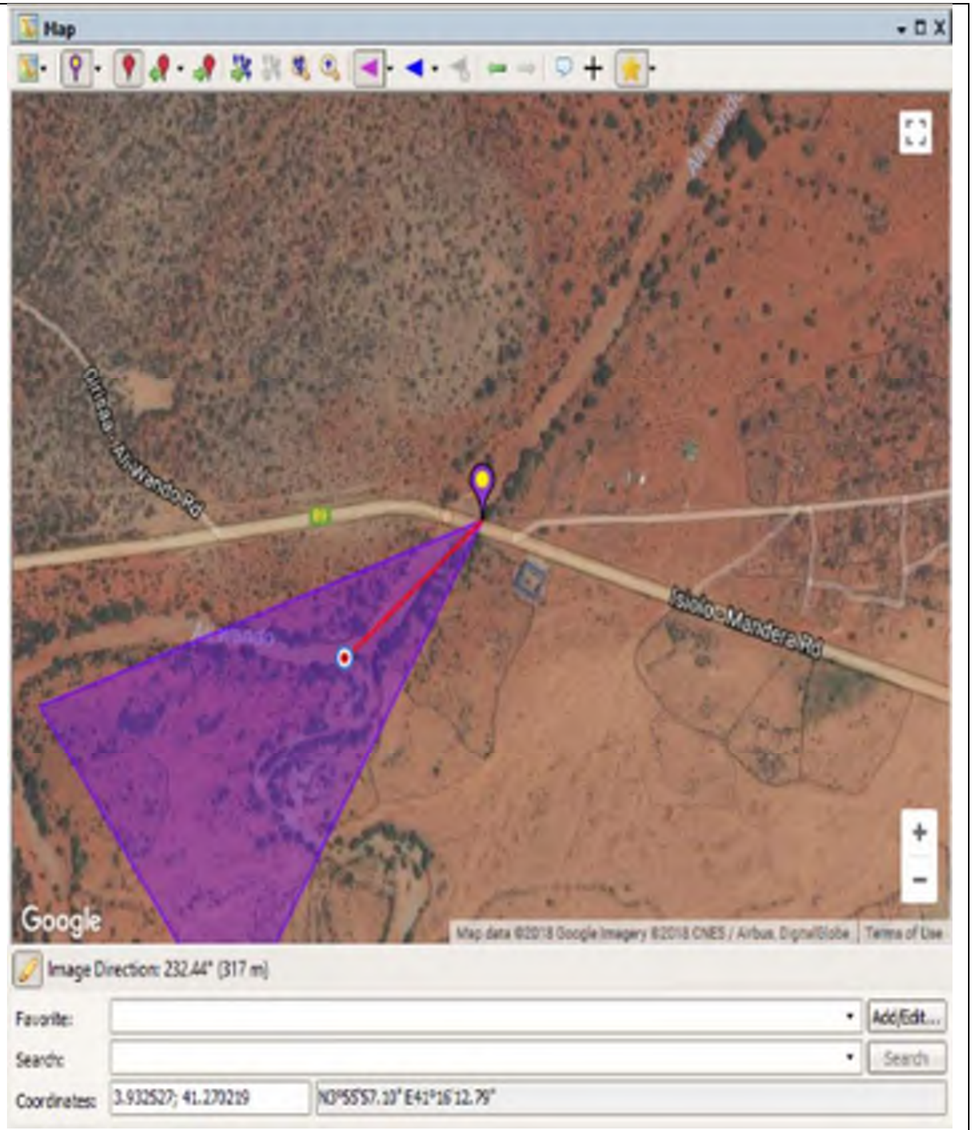


Description: Rhs view of the sandy river bed crossing of Ali Wando river

Coordinates: N3°55'57.10" E41°16'12.79"

Altitude: 233m

Point 81

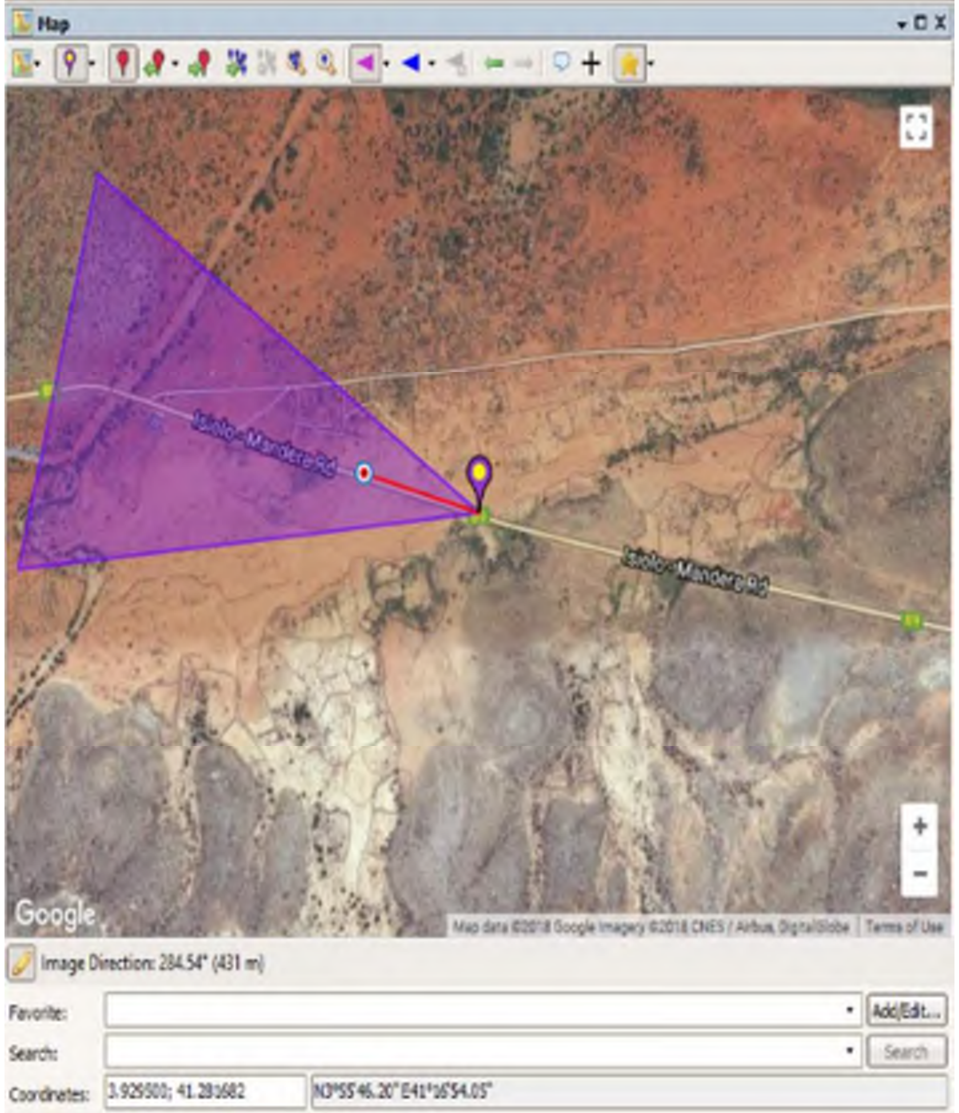


Description: Exposed twin culvert of diameter 900mm.

Coordinates: N3°55'46.20" E41°16'54.05"

Altitude: 213m

Point 82

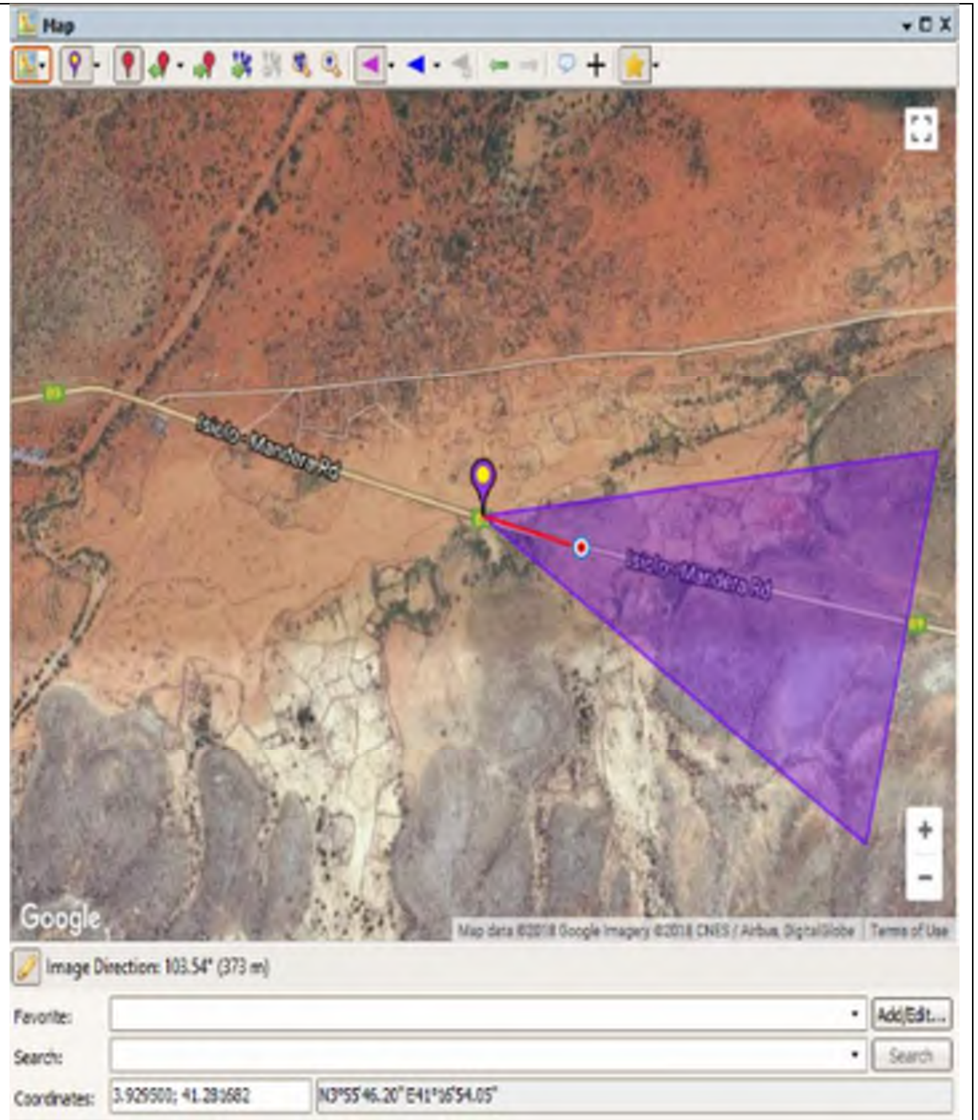


Description: Forward view of the approach road to a twin culvert of diameter 900mm eroded by the storm water.

Coordinates: N3°55'46.20" E41°16'54.05"

Altitude: 213m

Point 82

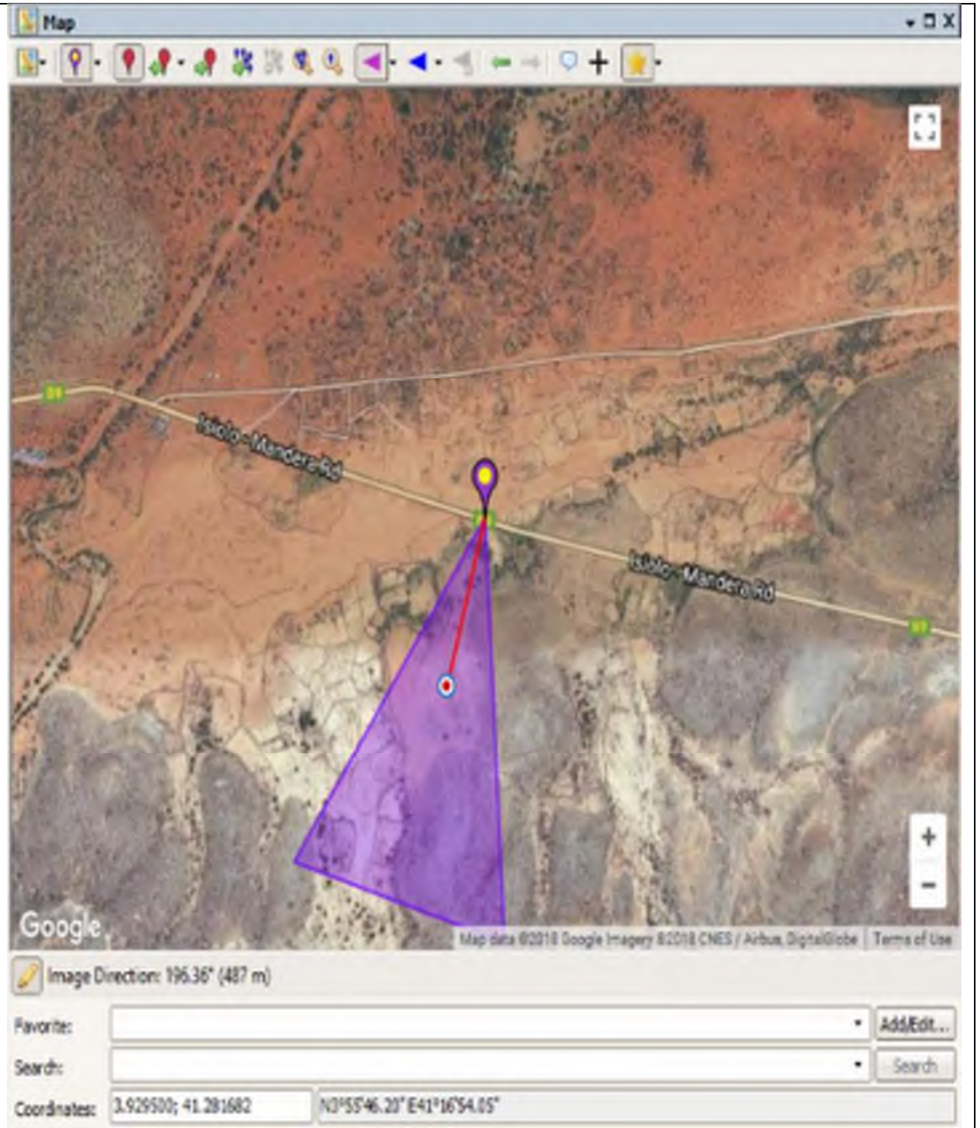


Description: Lhs view of a twin culvert of diameter 900mm eroded by the storm water.

Coordinates: N3°55'46.20" E41°16'54.05"

Altitude: 213m

Point 82



Description: Rhs view of twin culvert blocked by dry plants.

Coordinates: N3°55'46.20" E41°16'54.05"

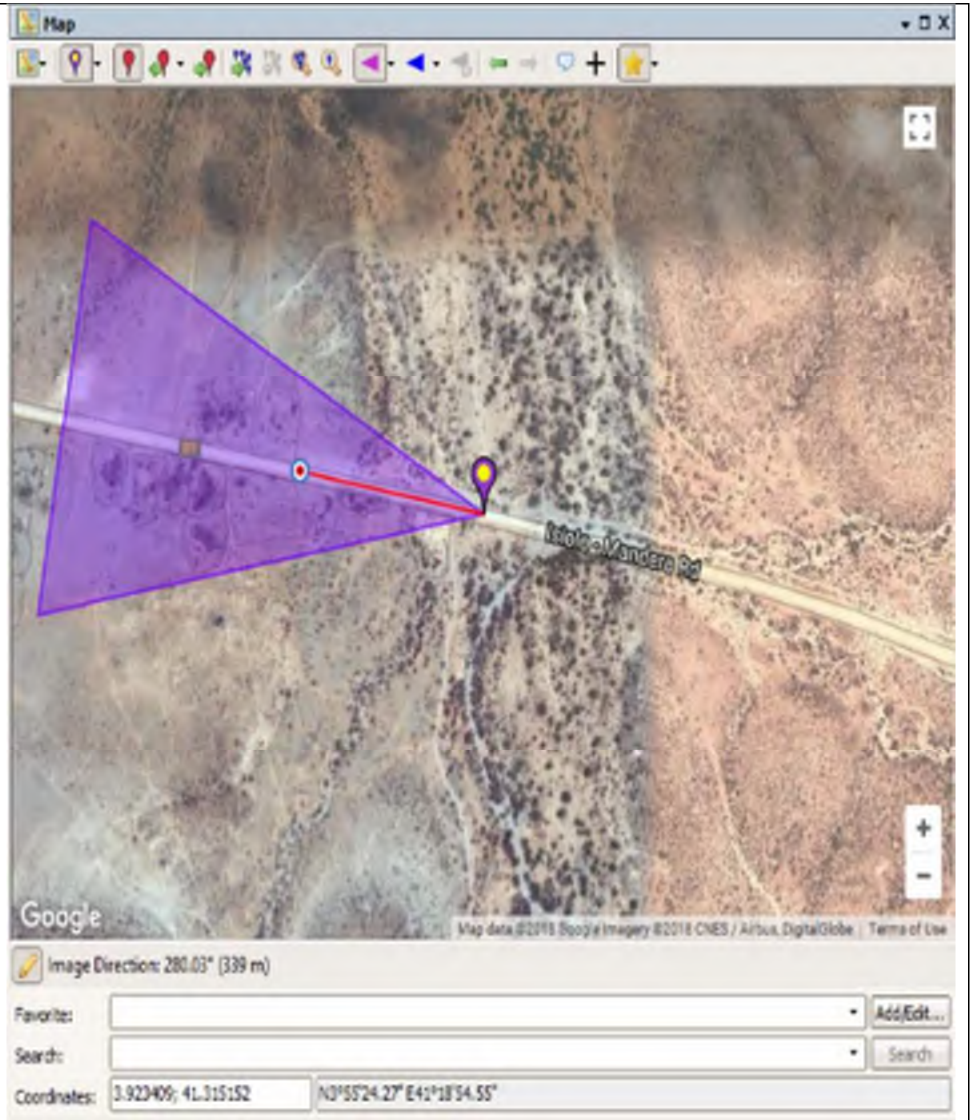
Altitude: 213m

Point 82

Description: Backward view of the approach road to a twin culvert of diameter 600mm. The area is relatively flat and swampy
Coordinates: N3°55'24.27" E41°18'54.55"

Altitude: 240m

Point 83

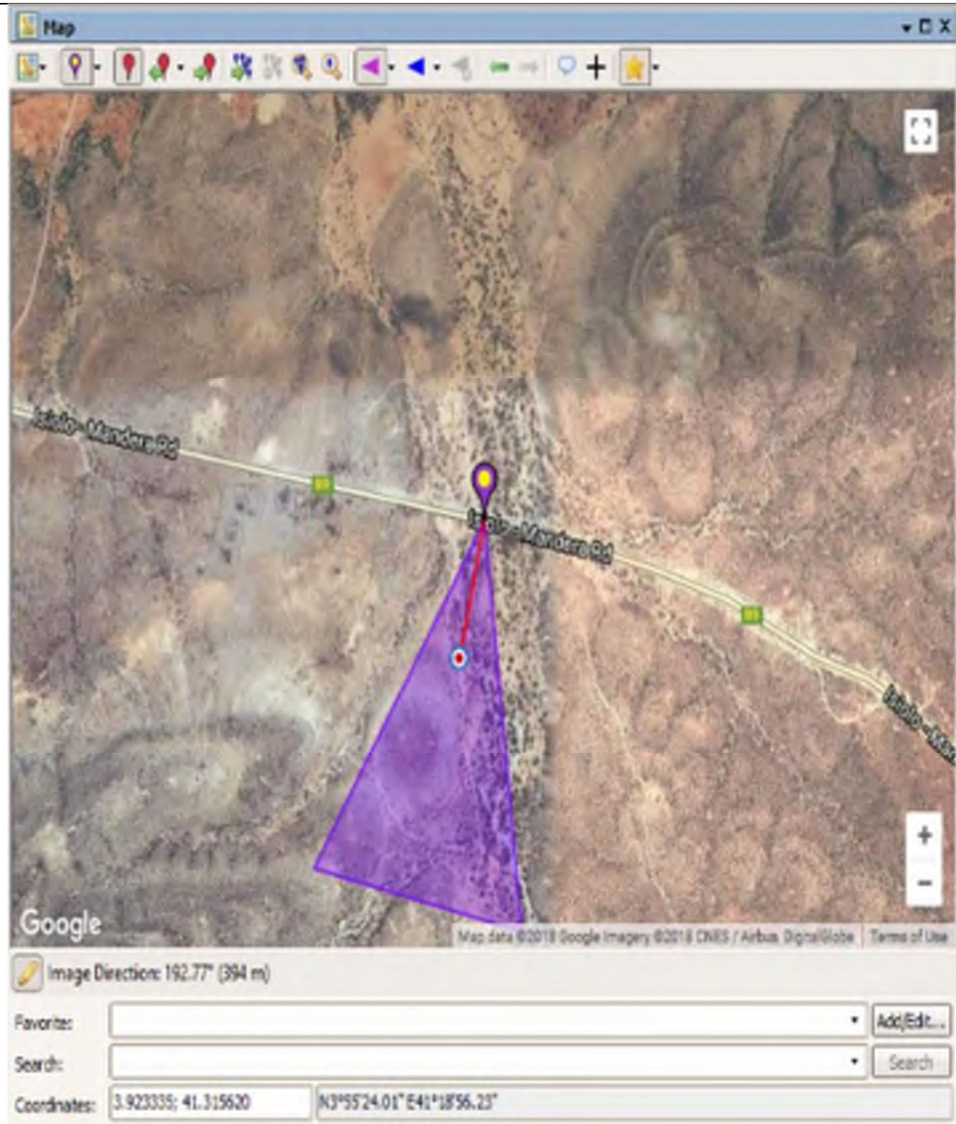


Description: Lhs view of the overgrown twin culvert of diameter 600mm.

Coordinates: N3°55'24.01" E41°18'56.23"

Altitude: 236m

Point 83

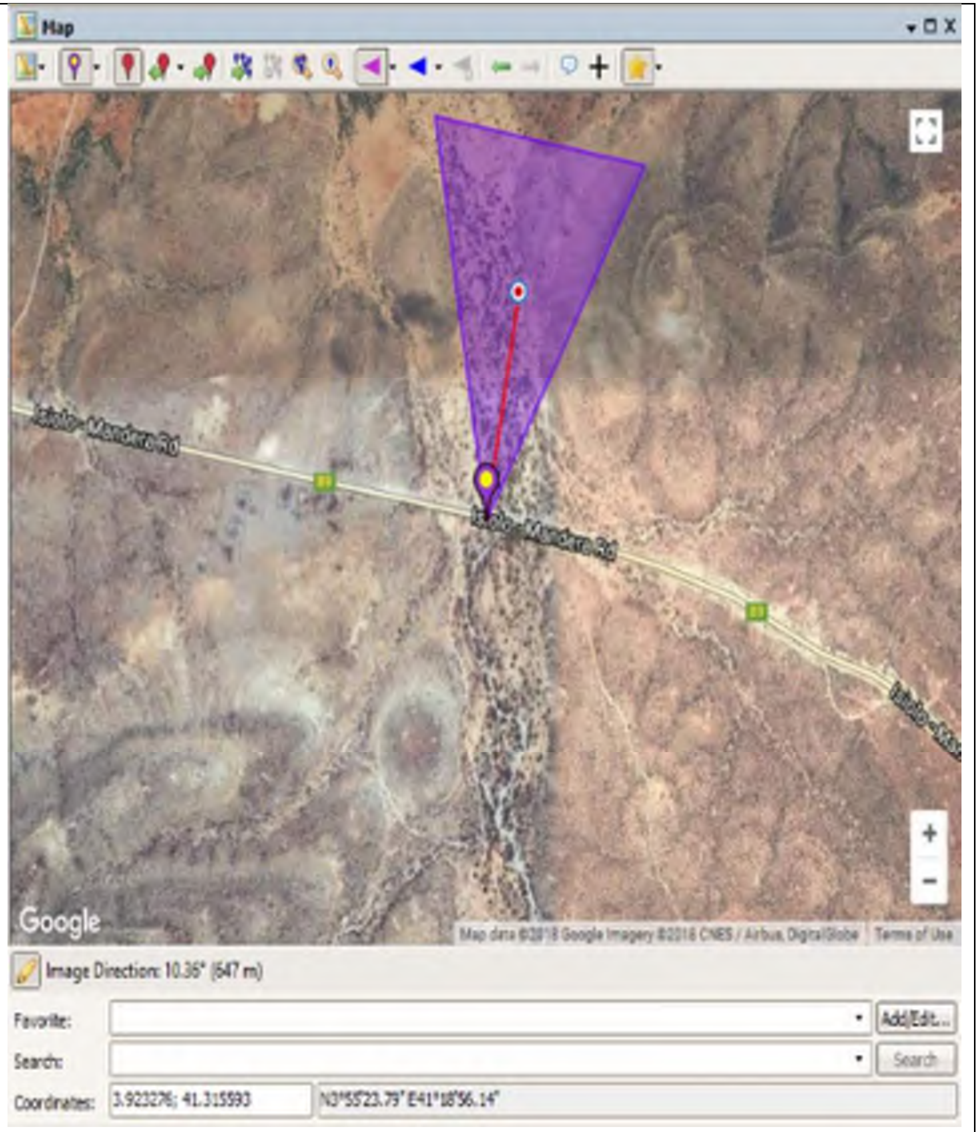


Description: Rhs view of the overgrown twin culvert of diameter 600mm.

Coordinates: N3°55'23.79" E41°18'56.14"

Altitude: 236m

Point 83

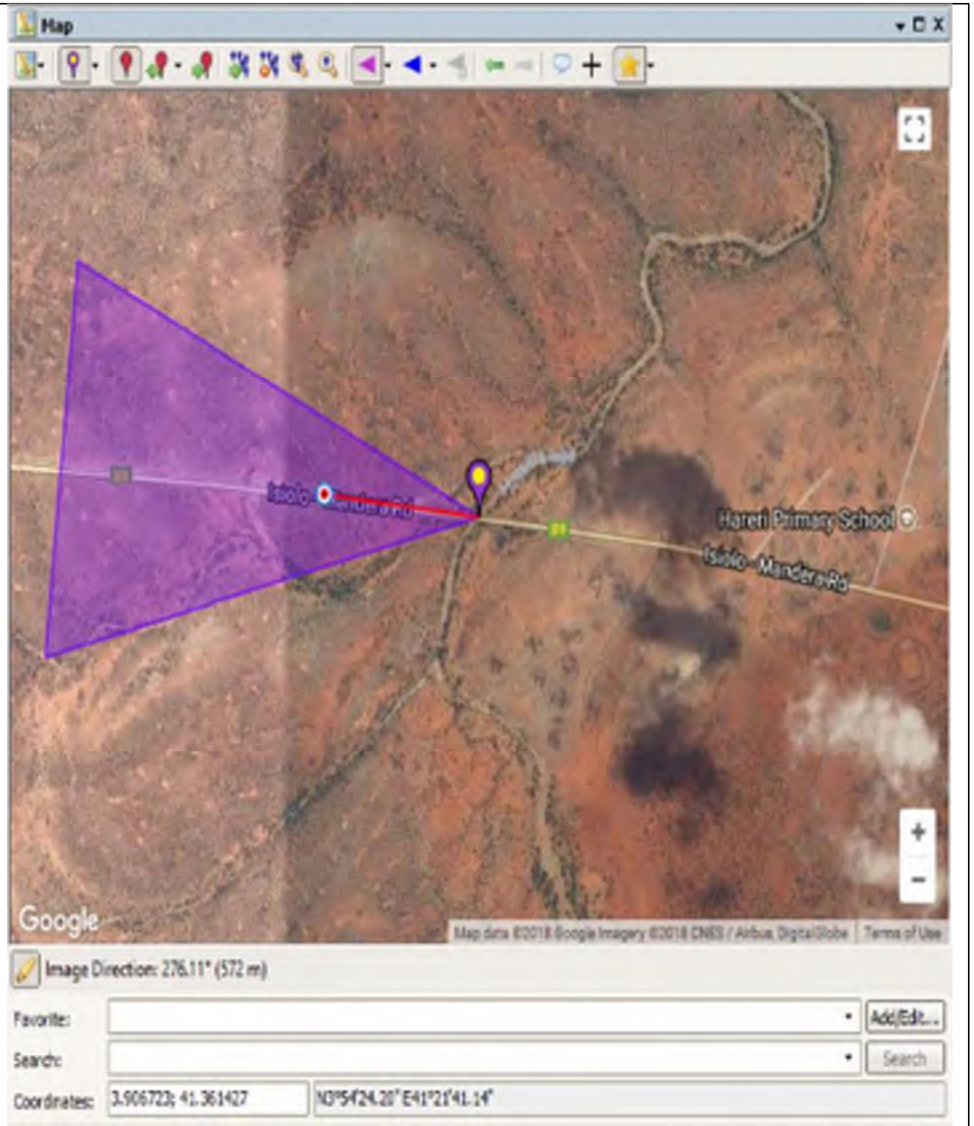


Description: drift section of about 30m wide with lots of sand and rocks on riverbed with photo taken in the backward direction

Coordinates: N3°54'24.20" E41°21'41.14"

Altitude: 270m

Point 85

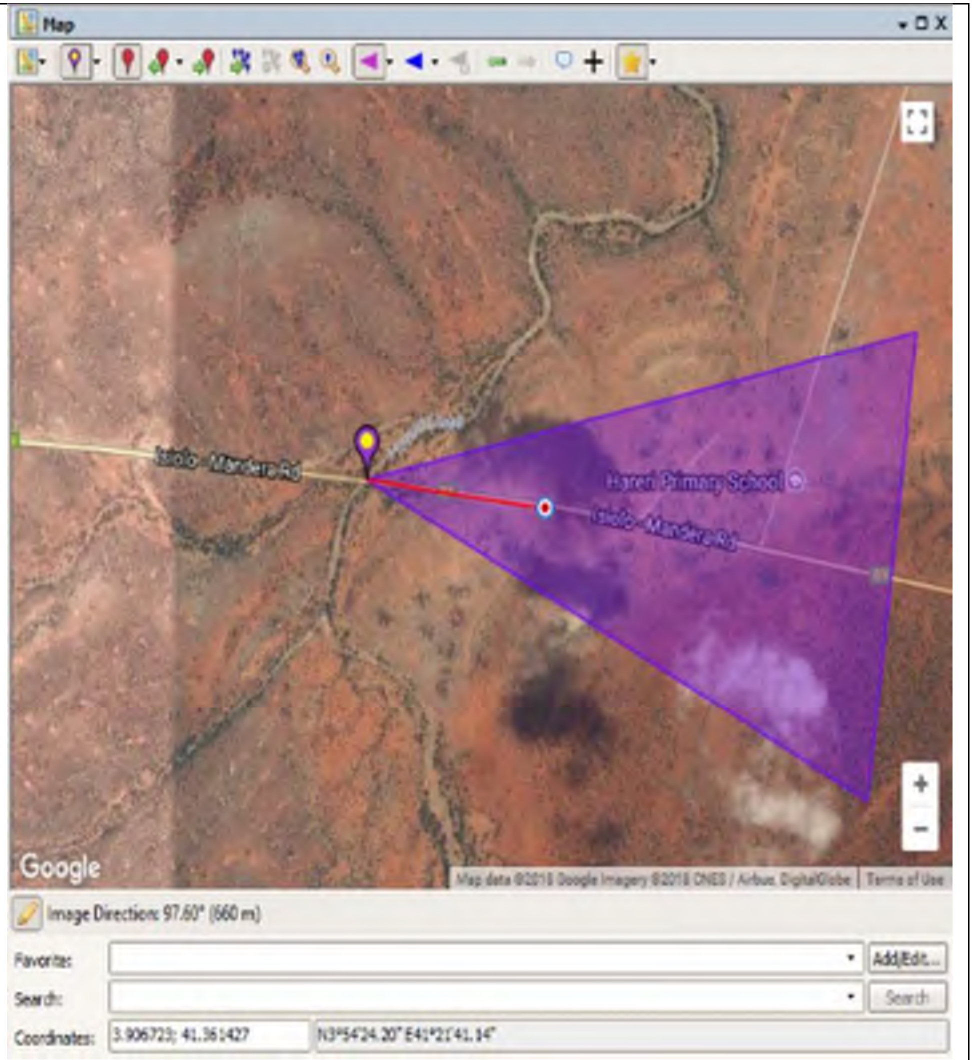


Description: drift section of about 30m wide with lots of sand and rocks on riverbed with photo taken in the forward direction

Coordinates: N3°54'24.20" E41°21'41.14"

Altitude: 270m

Point 85



Description: drift section of about 30m wide with lots of sand and rocks on riverbed with photo taken in the lhs direction

Coordinates: N3°54'23.98" E41°21'42.08"

Altitude: 281m

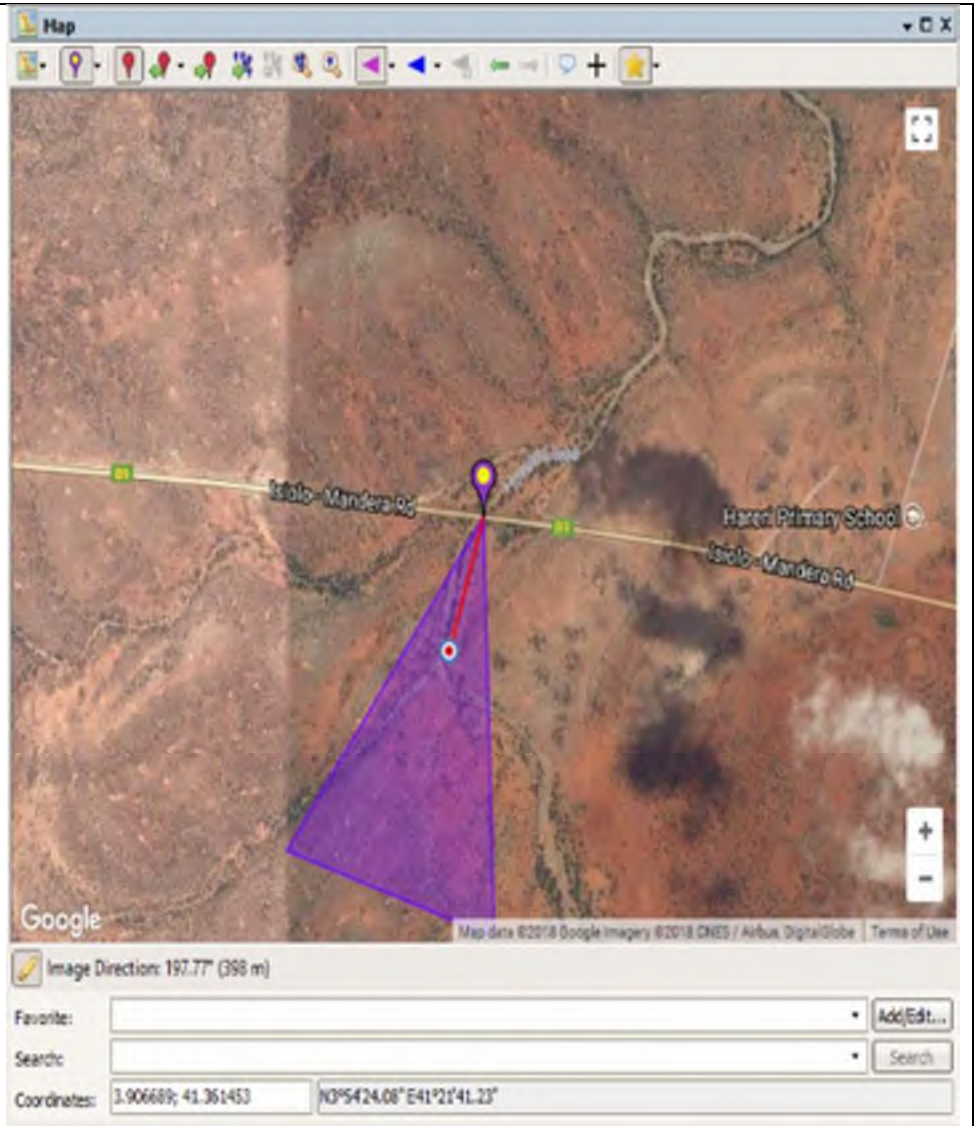
Point 85

Description: drift section of about 30m wide with lots of sand and rocks on riverbed with photo taken in the rhs direction.

Coordinates: N3°54'24.08" E41°21'41.23"

Altitude: 270m

Point 85

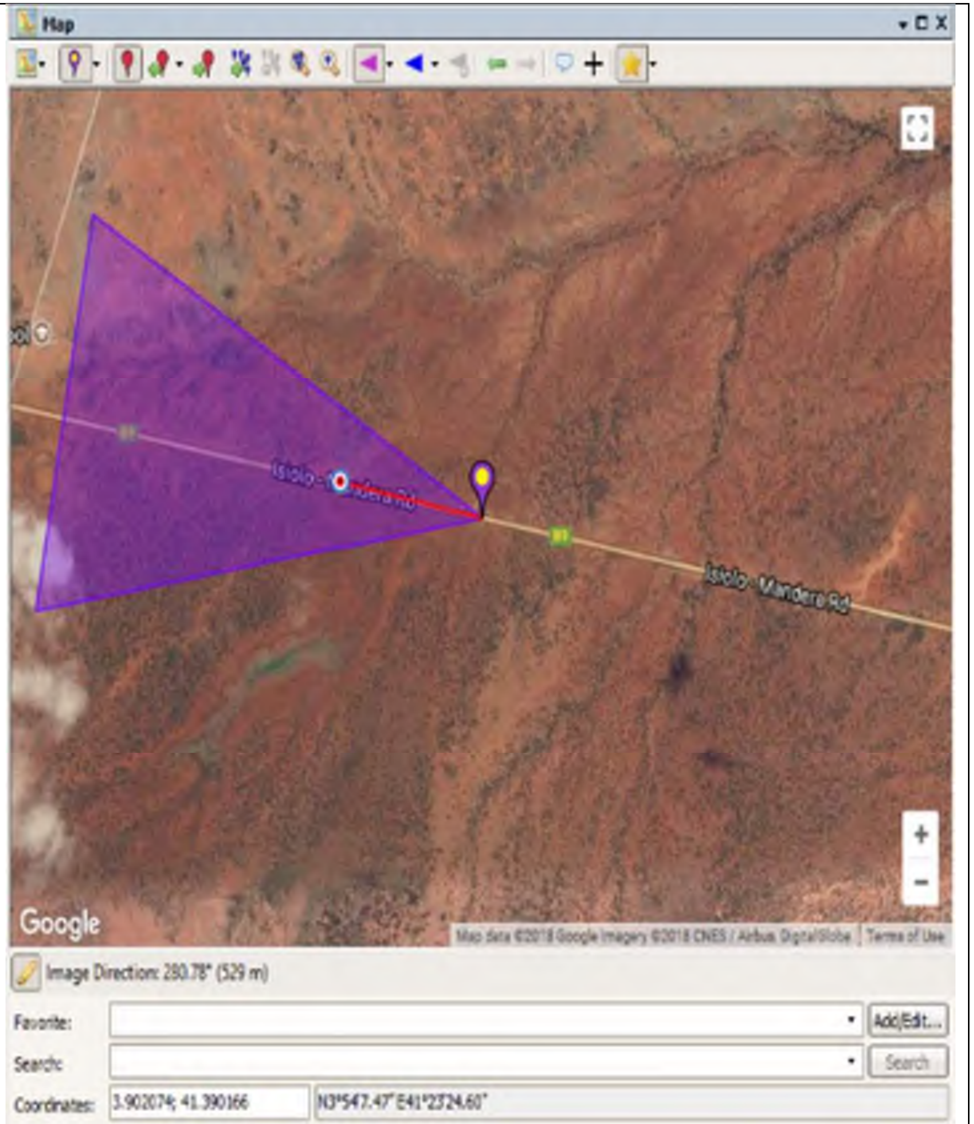


Description: Backward view of the approach roads to a vented drift section damaged with a hole from the top side of drift

Coordinates: N3°54'7.47" E41°23'24.60"

Altitude: 261m

Point 86

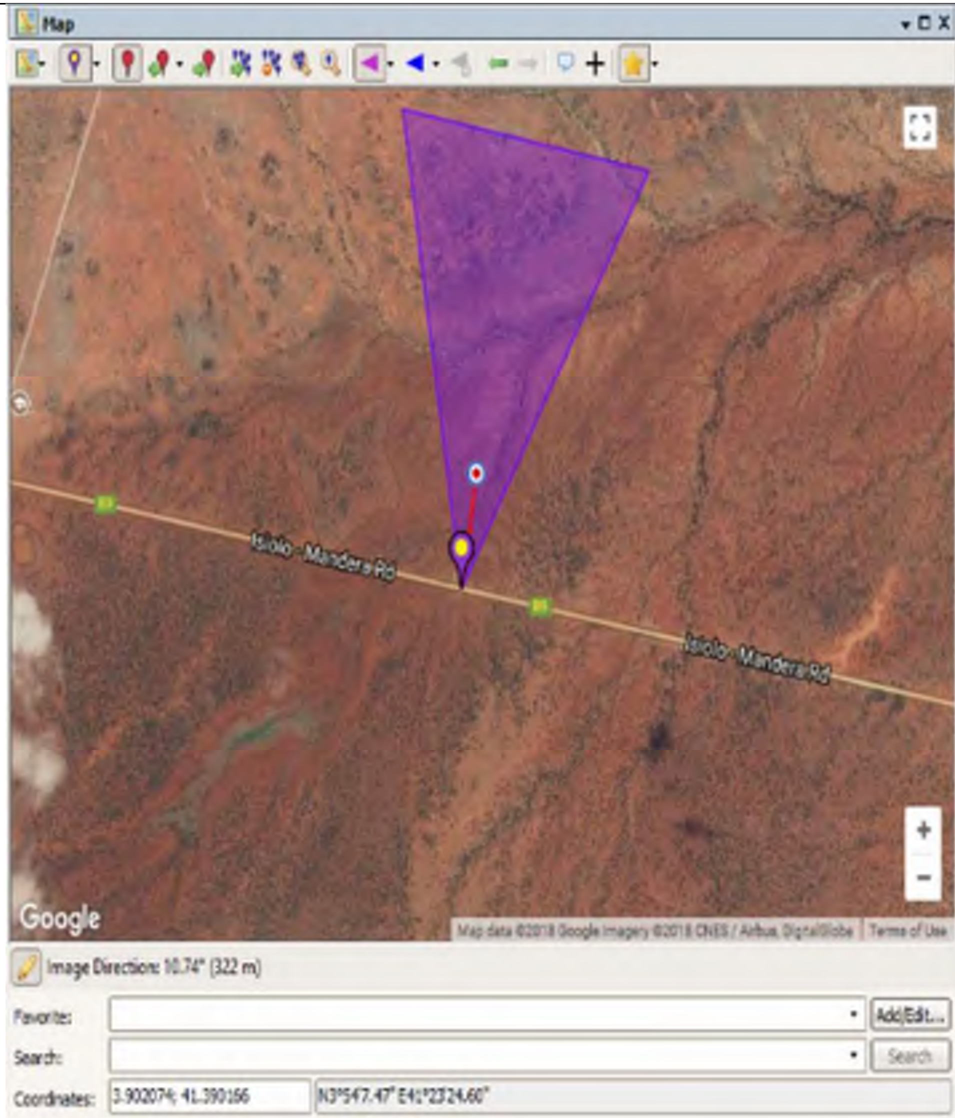


Description: Damaged section of the vented drift.

Coordinates: N3°54'7.47" E41°23'24.60"

Altitude: 261m

Point 86



Description: Lhs view of a Seriously scoured section of a drift. The scouring is about 2m.

Coordinates: N3°54'8.21" E41°23'24.25"

Altitude: 267m

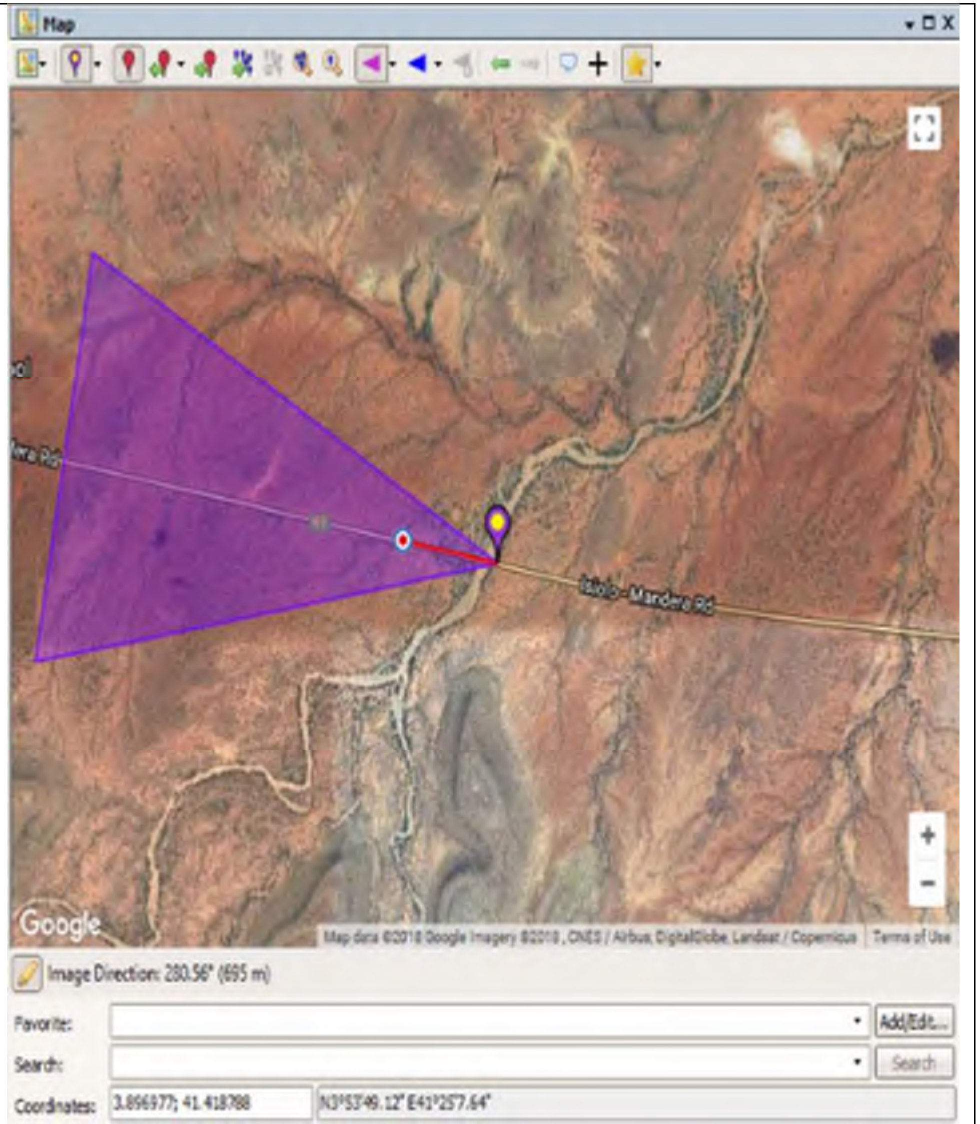
Point 86

Description: Backward view of the approach roads to a drift section about 120m long with lots of sand and stones on riverbed of both upstream and downstream.

Coordinates: N3°53'49.12" E41°25'7.64"

Altitude: 245m

Point 87

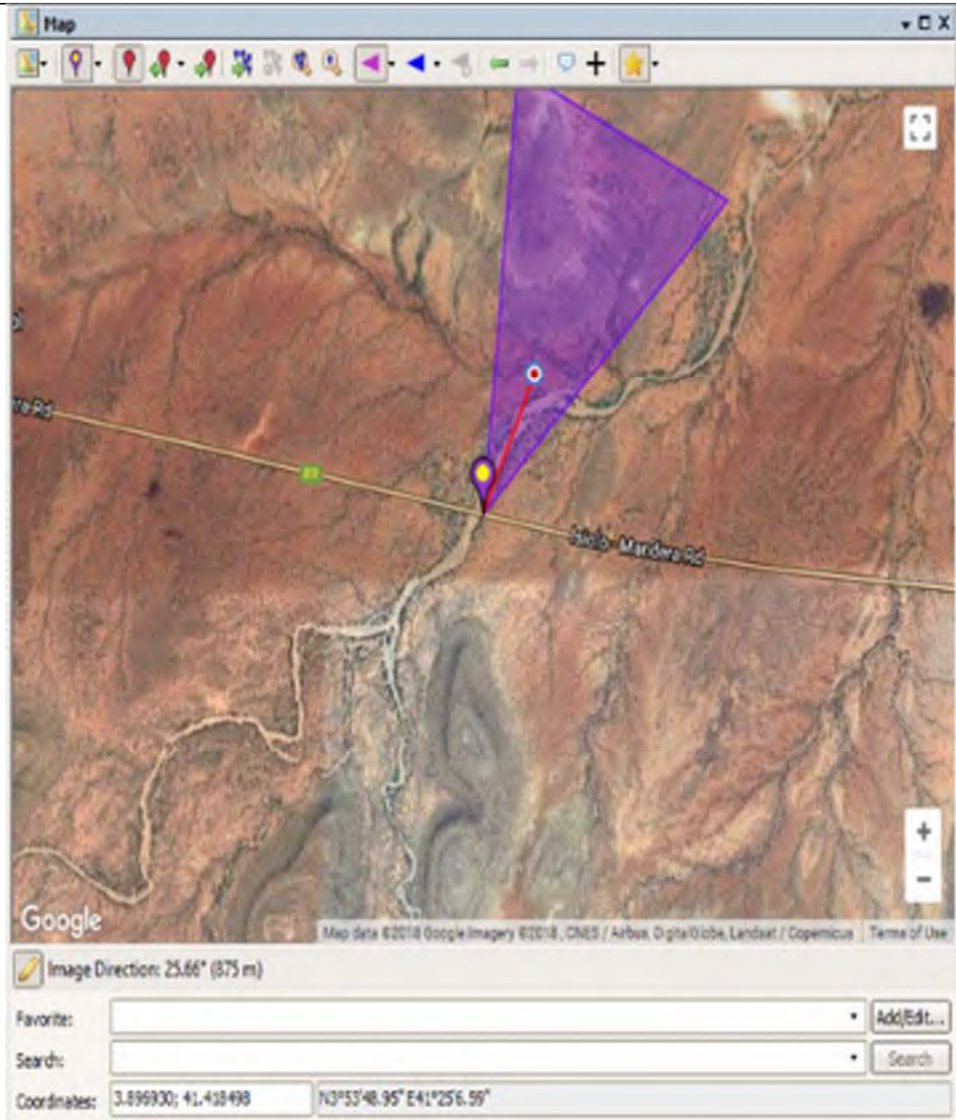


Description: Lhs view of drift section about 120m long with deposits of sand and stone.

Coordinates: N3°53'48.95" E41°25'6.59"

Altitude: 254m

Point 87

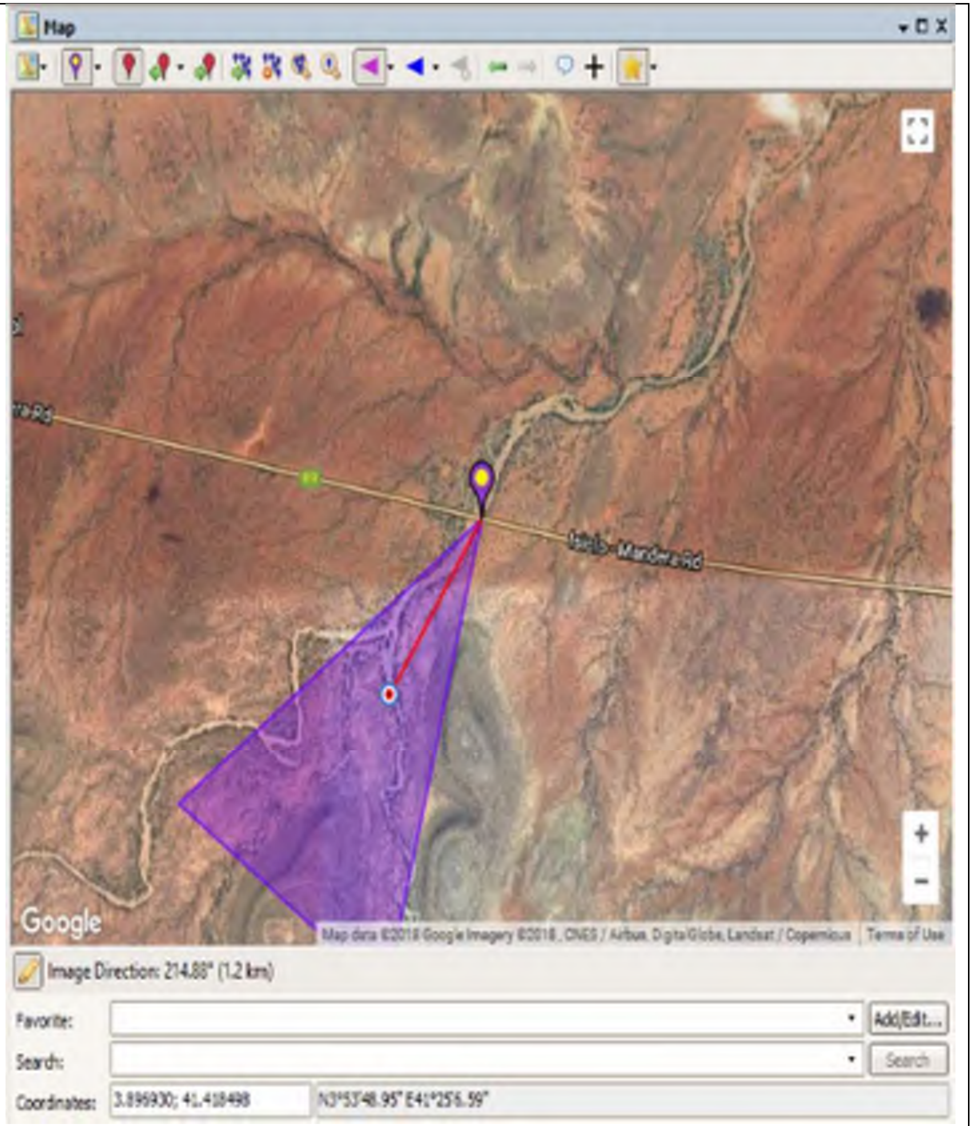


Description: Rhs view of drift section about 120m long with deposits of sand and stone.

Coordinates: N3°53'48.95" E41°25'6.59"

Altitude: 254m

Point 87

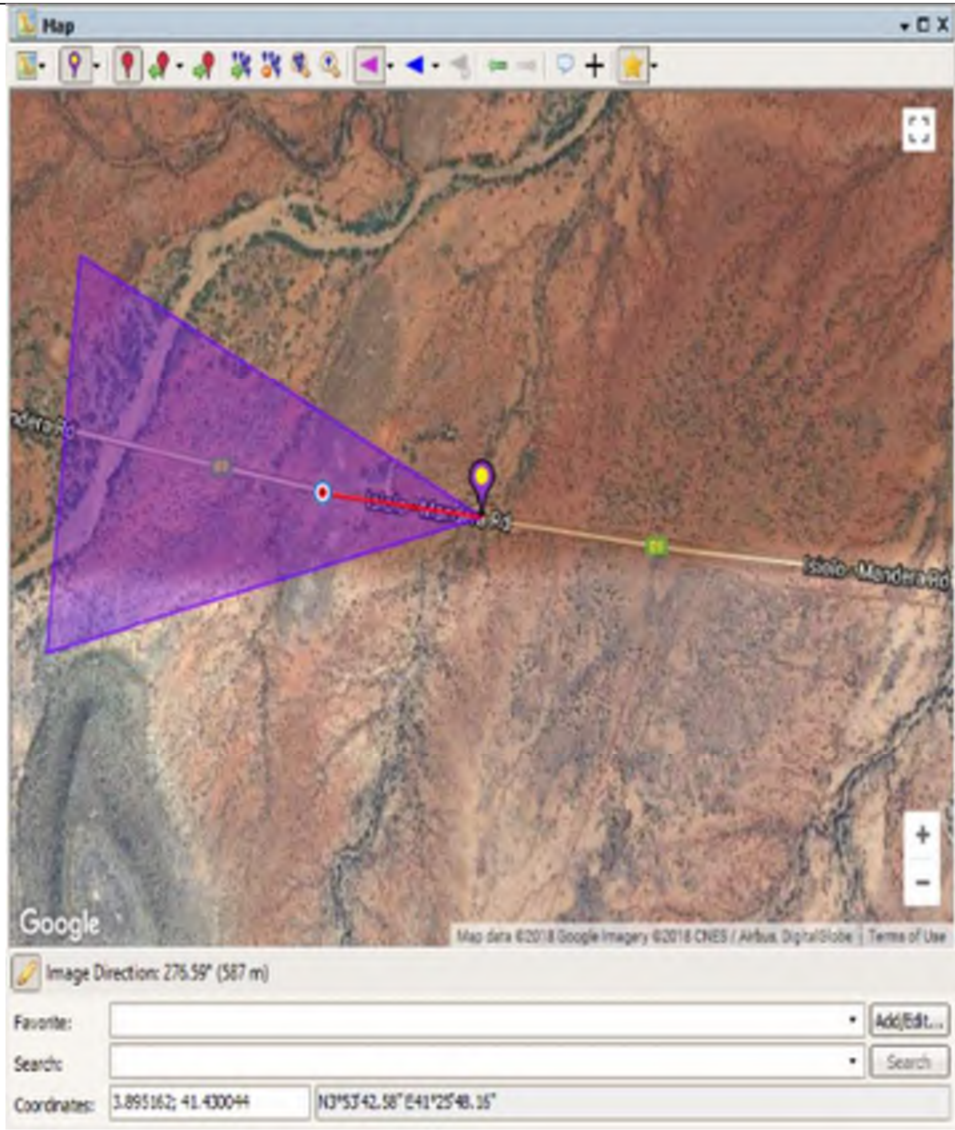


Description: Backward view of the approach roads to an area with triple culvert of diameter 600mm.

Coordinates: N3°53'42.58" E41°25'48.16"

Altitude: 241m

Point 89

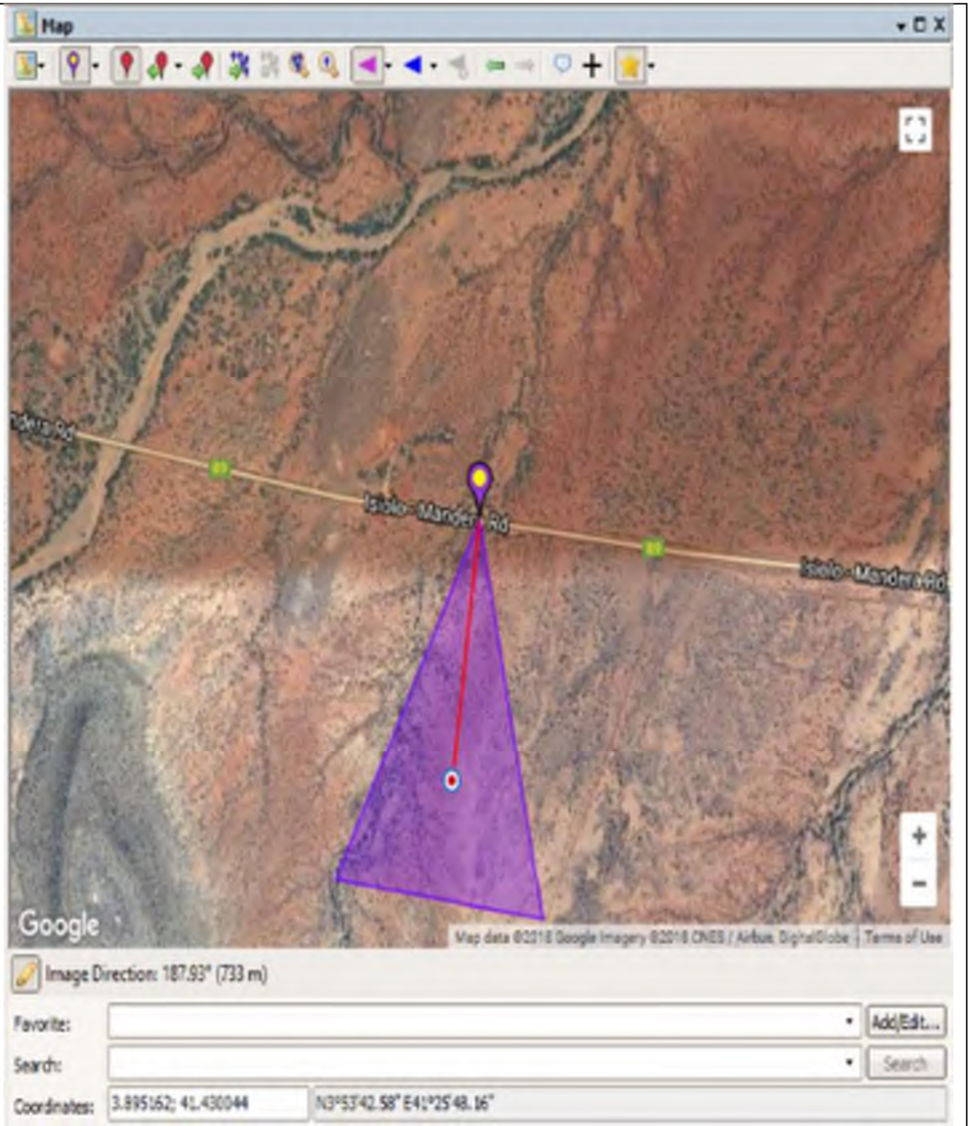


Description: Lhs view of a triple culvert of diameter 600mm. The gabions on left side are damaged and eroded. The section has lots of sand on riverbed with large stones with photo taken in the right direction

Coordinates: N3°53'42.58" E41°25'48.16"

Altitude: 241m

Point 89



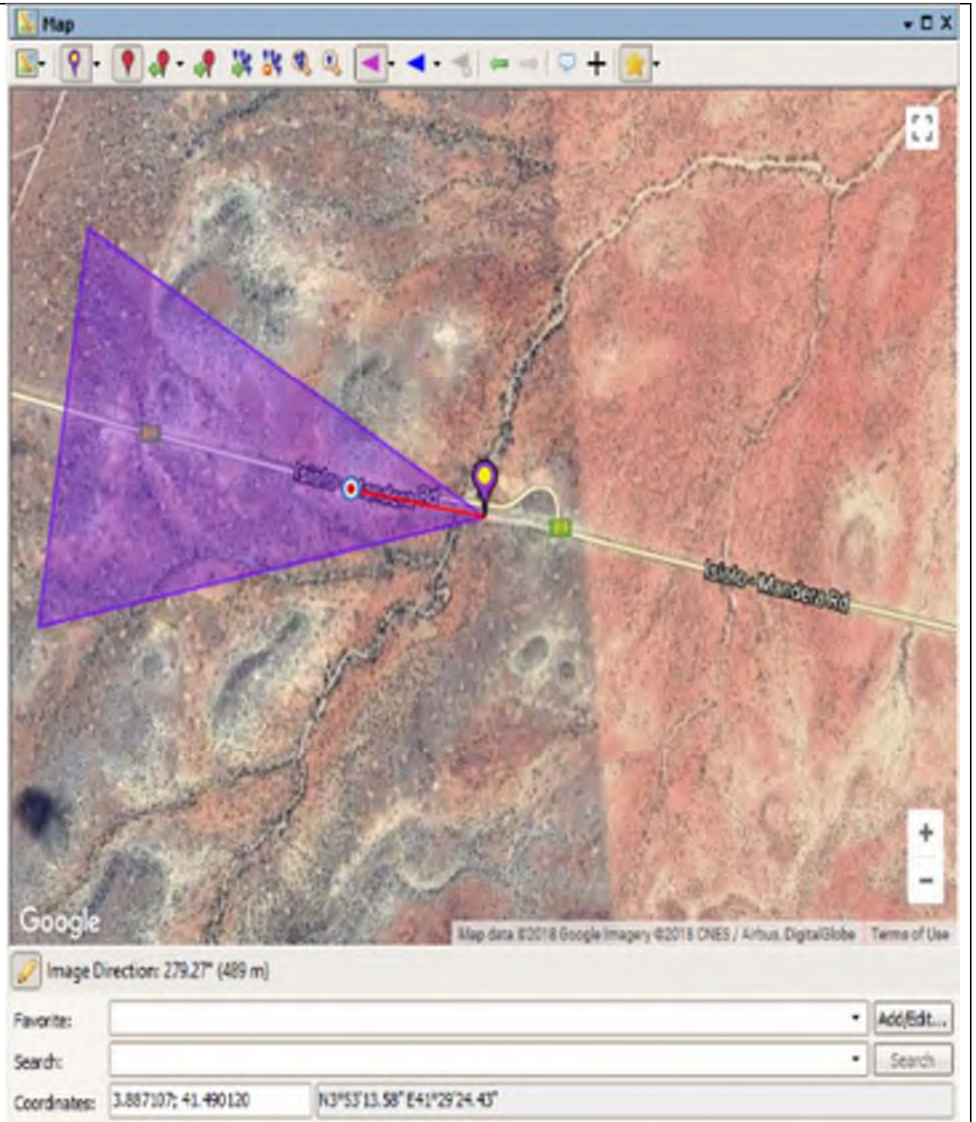
Description: Rhs view of a triple culvert of diameter 600mm.
Coordinates: N3°53'43.42" E41°25'47.58"
Altitude: 241m
Point 89

Description: Backward view of the approach roads to a twin box culvert section of 6x3m.

Coordinates: N3°53'13.58" E41°29'24.43"

Altitude: 250m

Point 91

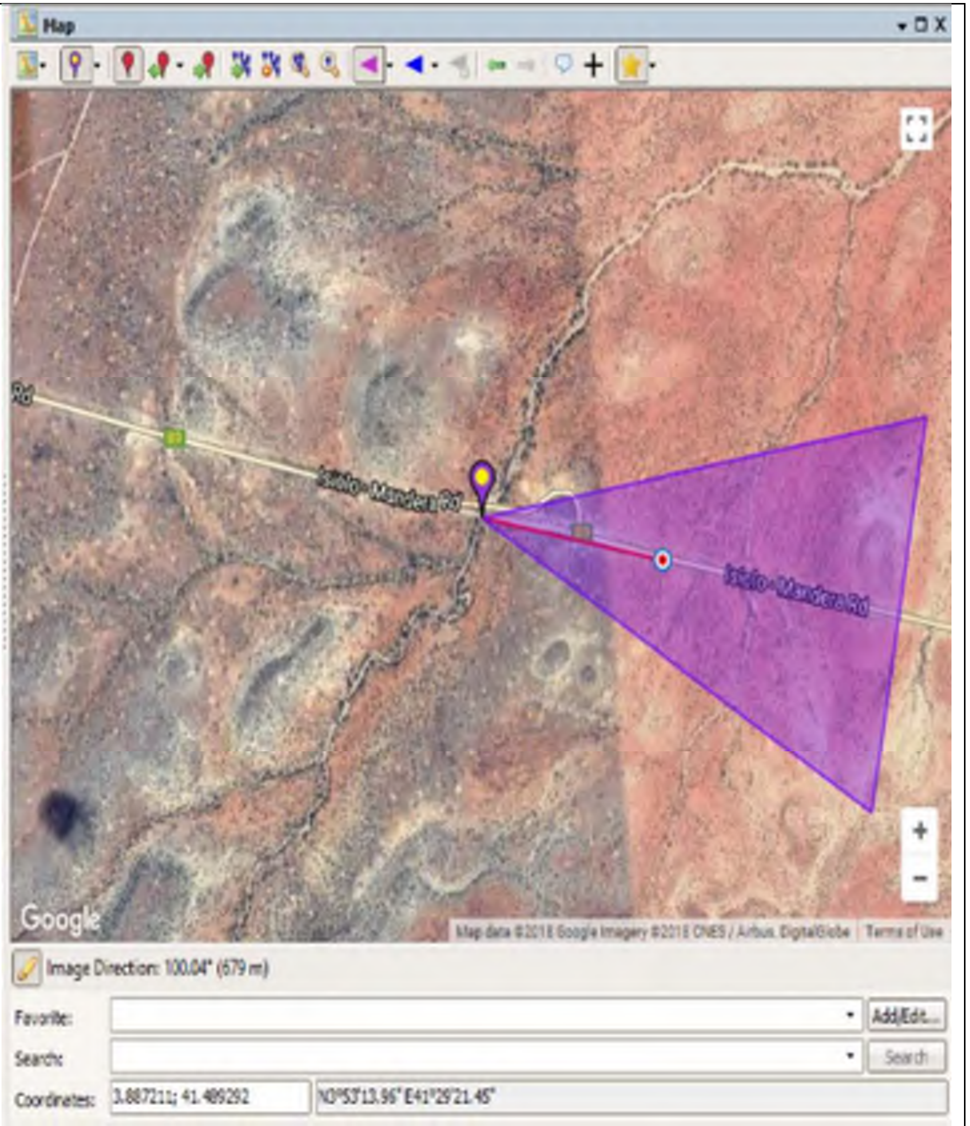


Description: Forward view of the approach roads to a twin box culvert section of 6x3m.

Coordinates: N3°53'13.96" E41°29'21.45"

Altitude: 250m

Point 91

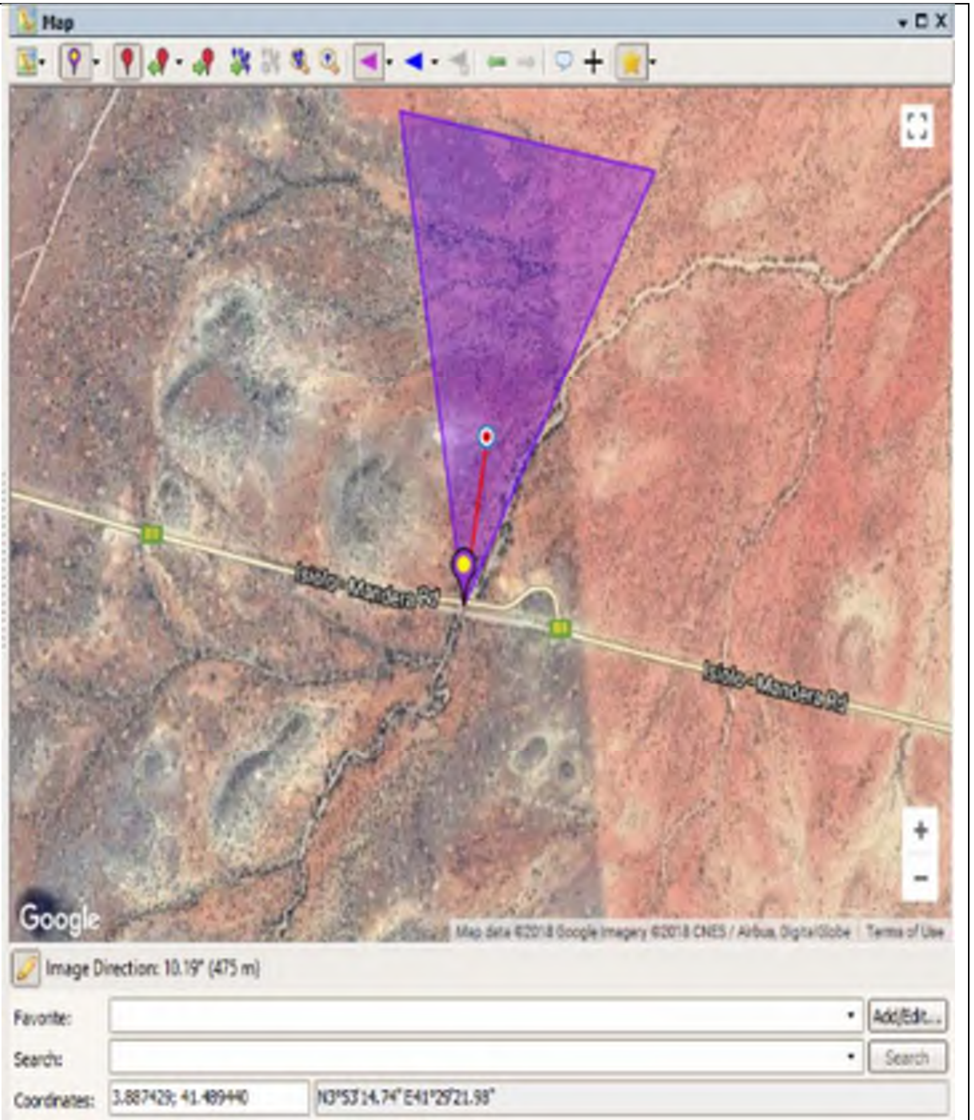


Description: Rhs view of a twin box culvert section of 6x3m.

Coordinates: N3°53'14.74" E41°29'21.98"

Altitude: 250m

Point 91

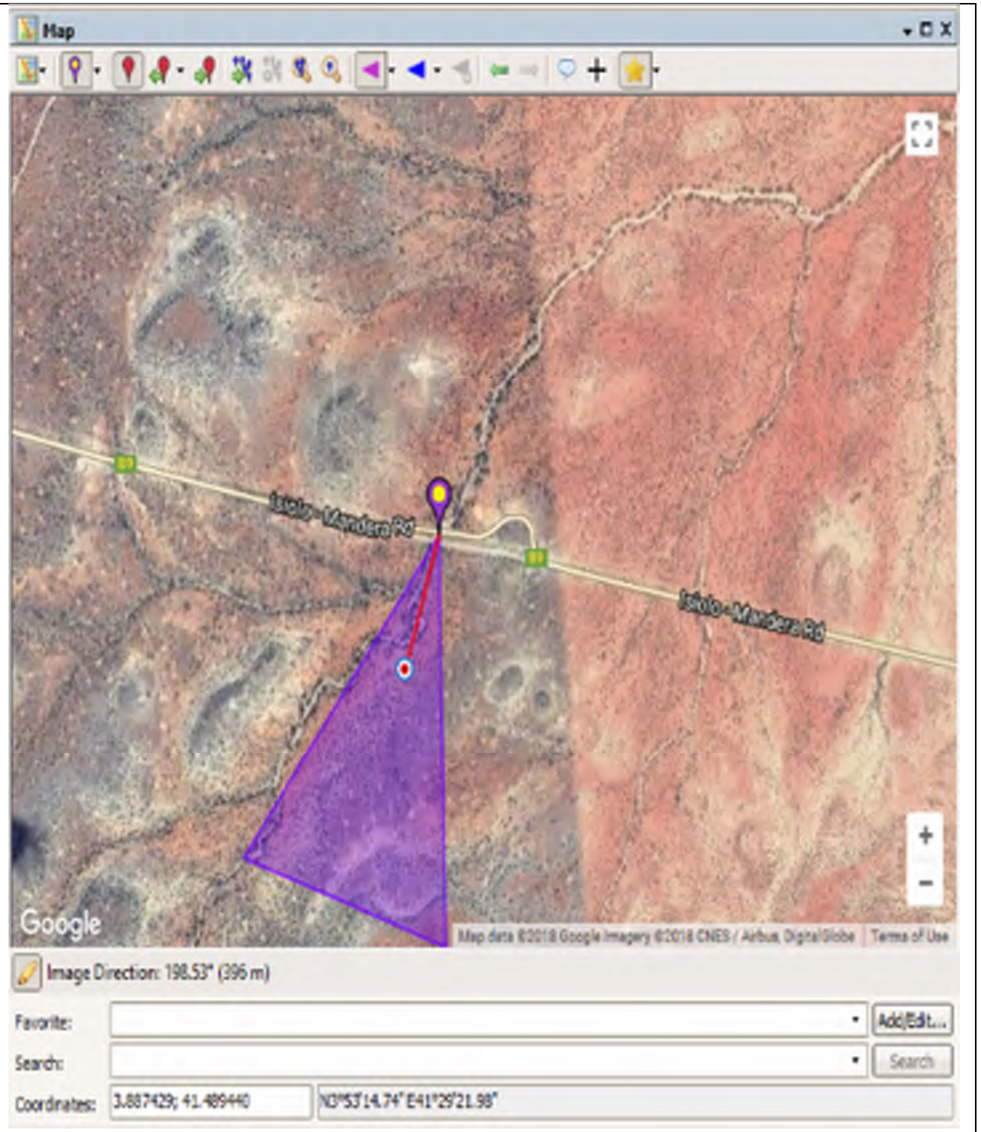


Description: Lhs view of a twin box culvert section of 6x3m. The stone pitching and the toe of the culvert have been scored by storm water.

Coordinates: N3°53'14.74" E41°29'21.98"

Altitude: 250m

Point 91

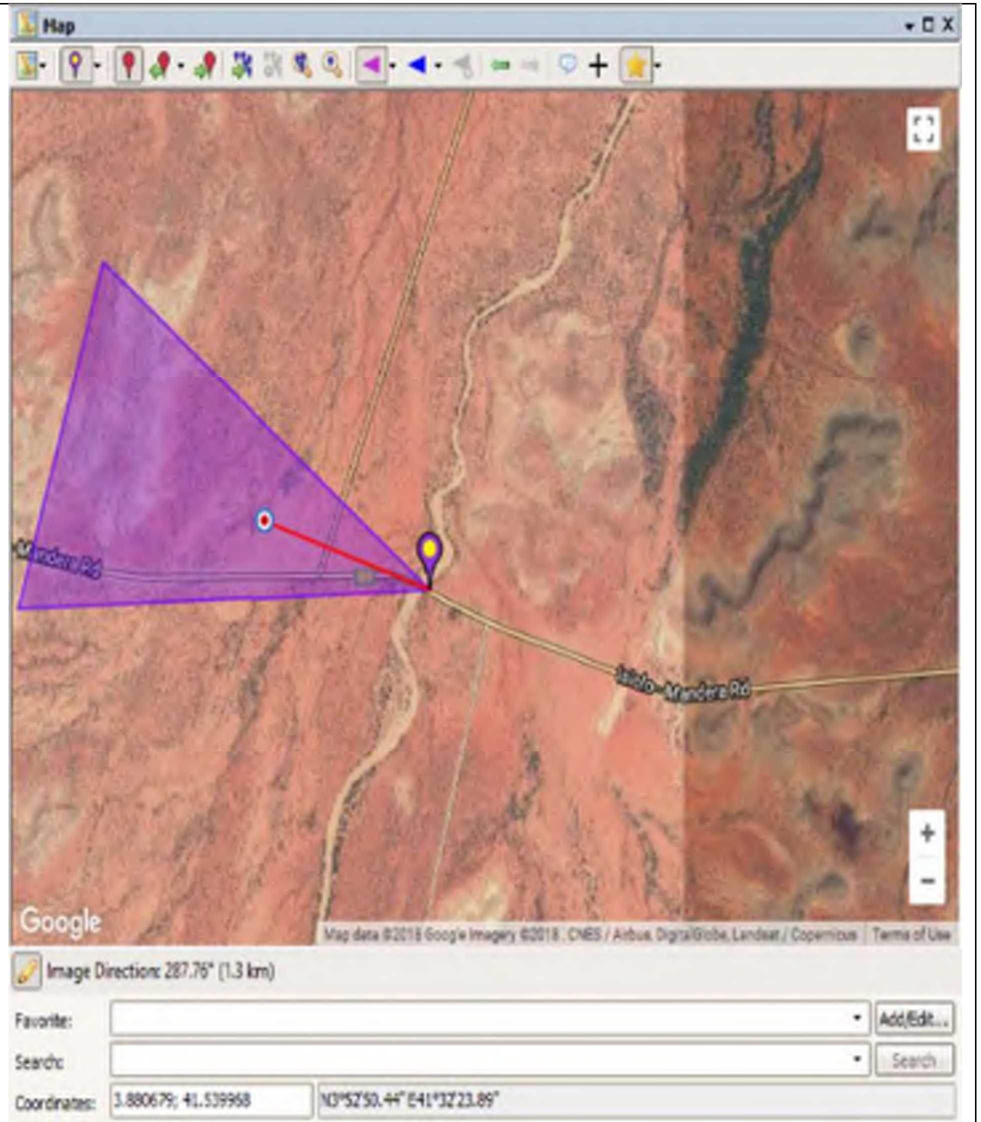


Description: Backward view of a drift section about 200m long with lots of silt on the riverbed. The downstream edge of the drift has been scoured to a depth of 1m.

Coordinates: N3°52'50.44" E41°32'23.89"

Altitude: 233m

Point 92

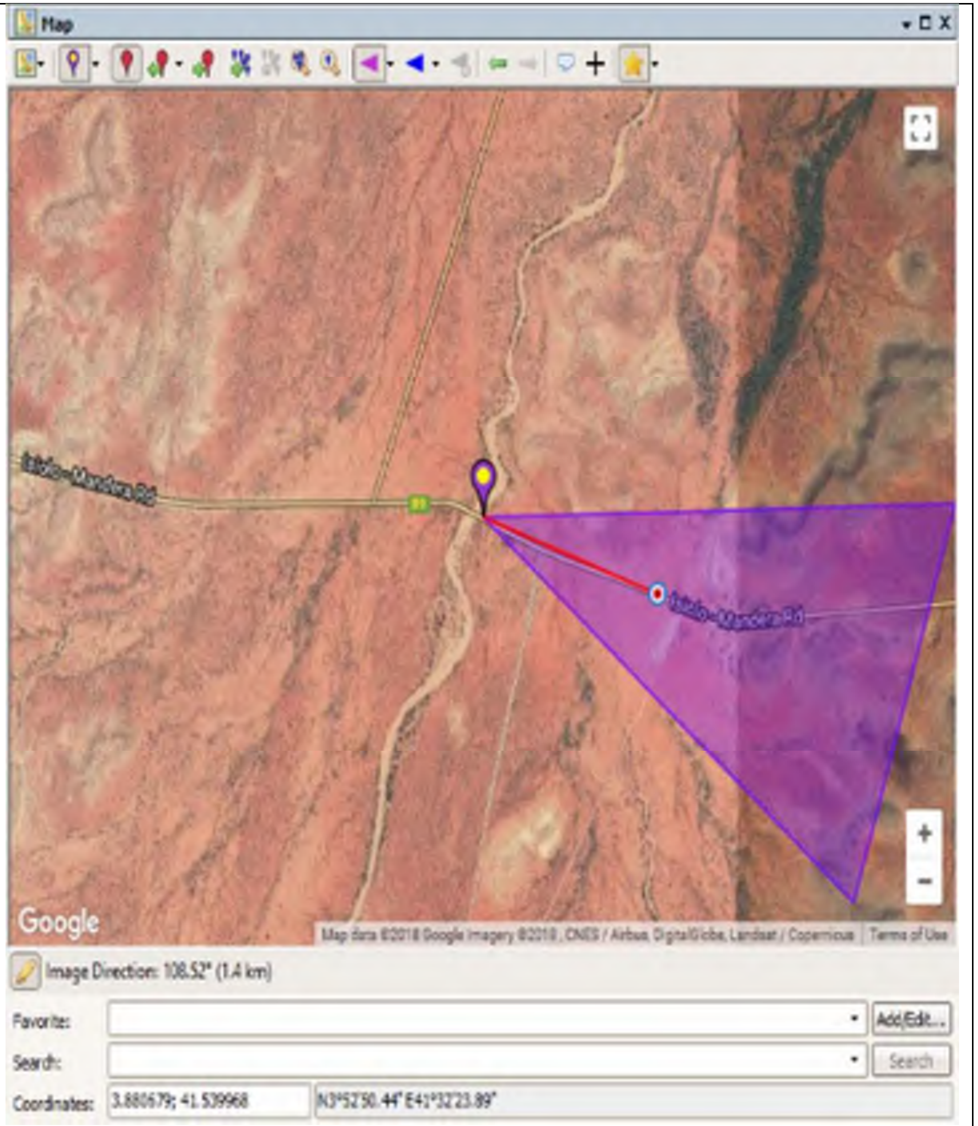


Description: Forward view of a drift section about 200m long with lots of silt on the riverbed.

Coordinates: N3°52'50.44" E41°32'23.89"

Altitude: 233m

Point 92

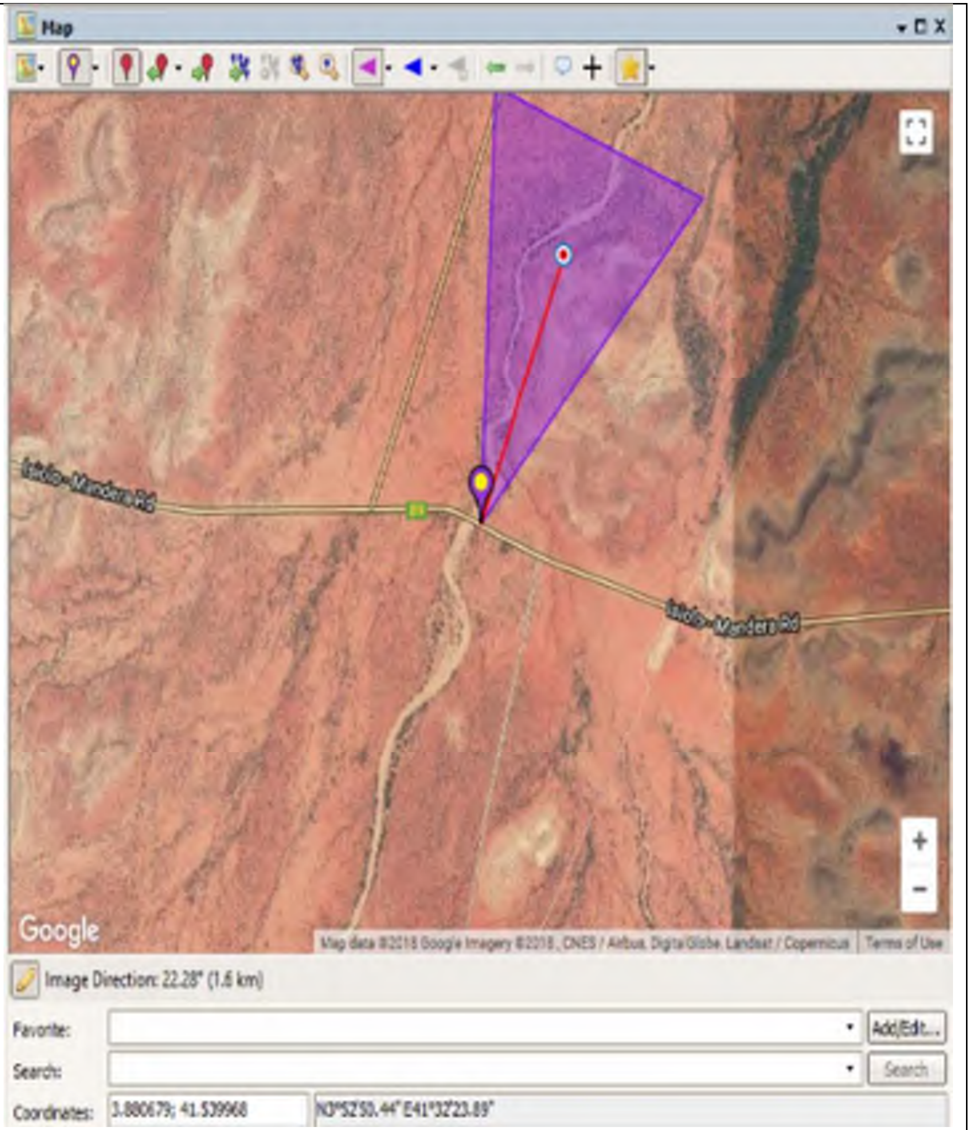


Description: Downstream view on the lhs of a drift section about 200m long with lots of silt on the riverbed. There are signs of scouring of about 1m.

Coordinates: N3°52'50.44" E41°32'23.89"

Altitude: 233m

Point 92

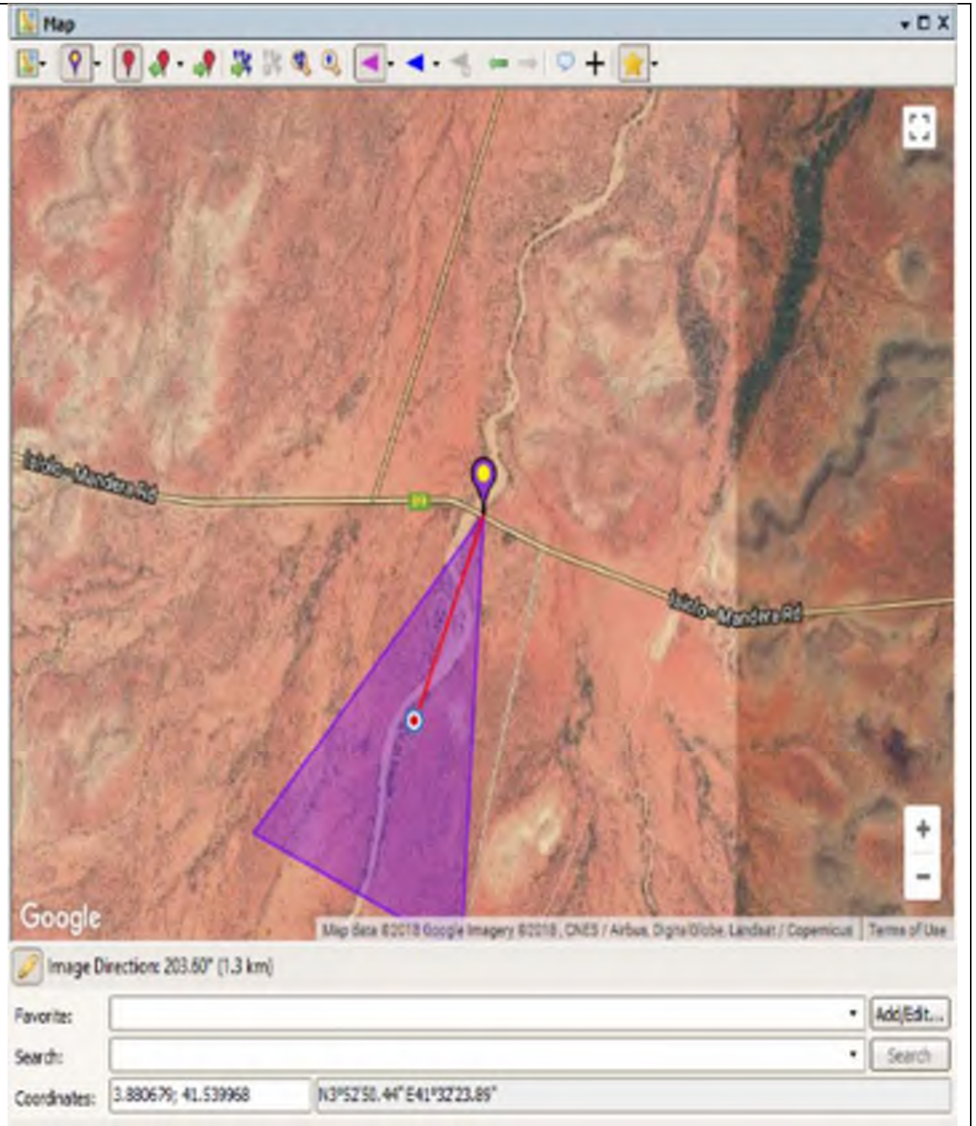


Description: Upstream view on the lhs of a drift section about 200m long with lots of silt on the riverbed.

Coordinates: N3°52'50.44" E41°32'23.89"

Altitude: 233m

Point 92

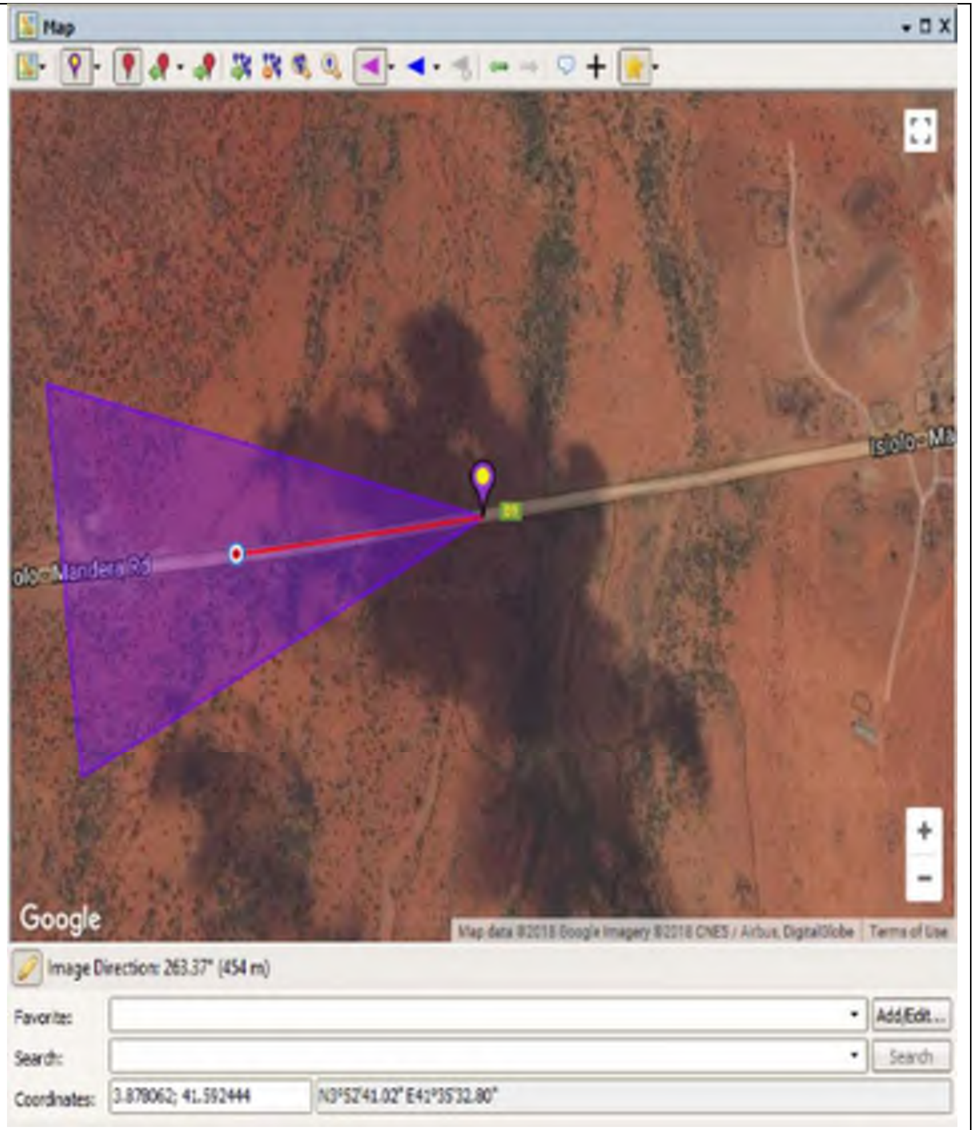


Description: Backward view of a drift section about 200m long, with wide riverbeds of about 150m and filled with silt.

Coordinates: N3°52'41.02" E41°35'32.80"

Altitude: 232m

Point 94

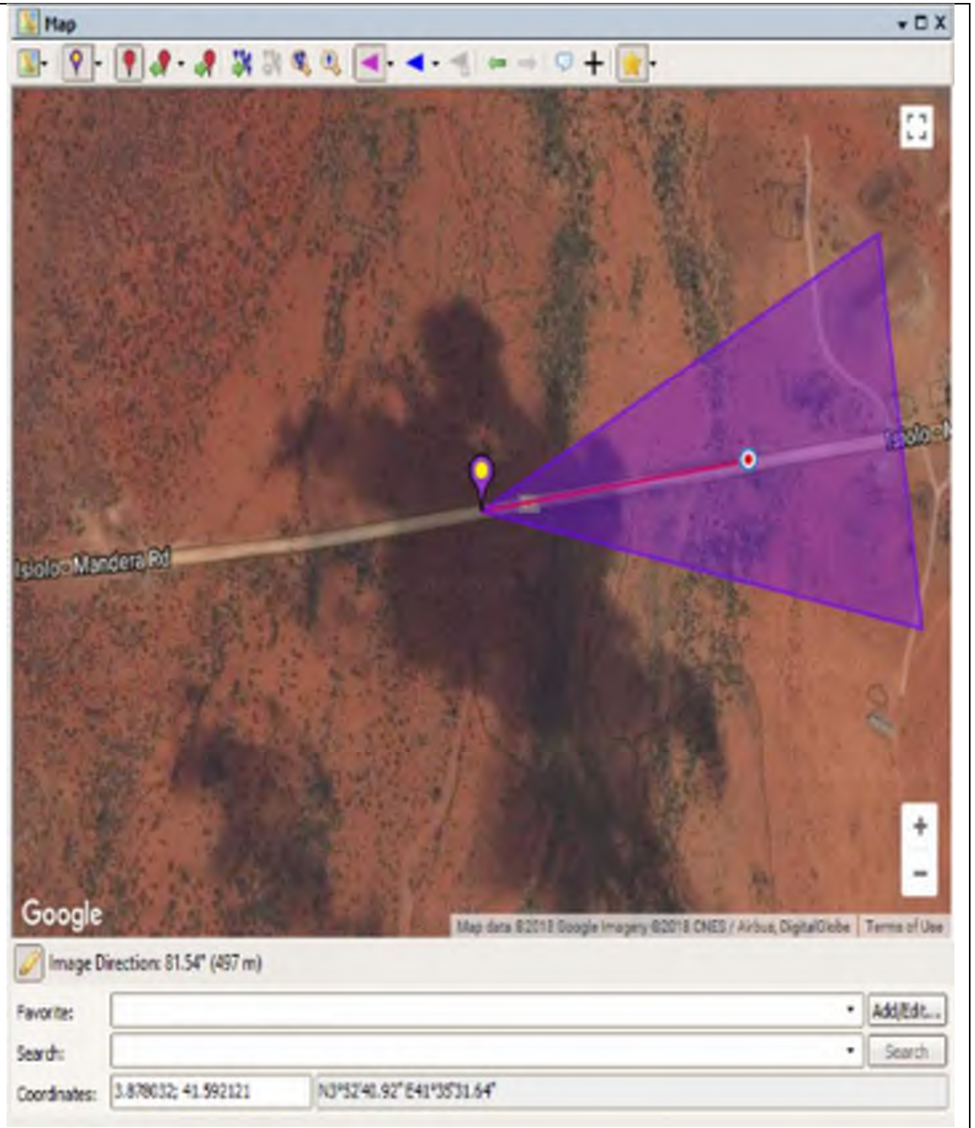


Description: Forward view of a drift section about 200m long, with wide riverbeds of about 150m and filled with silt.

Coordinates: N3°52'40.92" E41°35'31.64"

Altitude: 232m

Point 94



Description: Lhs view of a drift section about 200m long, with wide riverbeds of about 150m and filled with silt and stones. There are signs of scouring to depths of about 2m on the downstream riverbed.

Coordinates: N3°52'40.86" E41°35'32.09"

Altitude: 232m

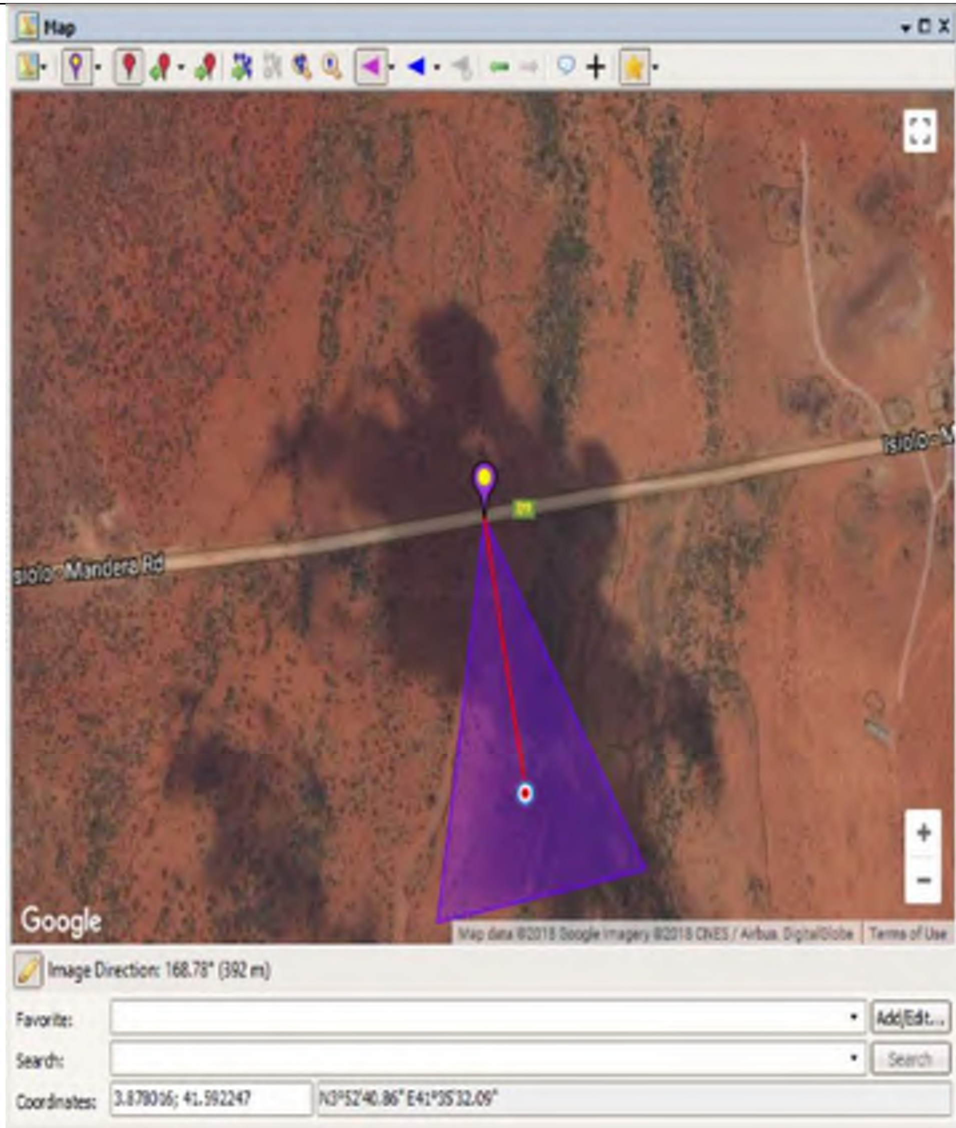
Point 94

Description: Rhs view of a drift section about 200m long, with wide riverbeds of about 150m and filled with silt and stones.

Coordinates: N3°52'40.86" E41°35'32.09"

Altitude: 232m

Point 94

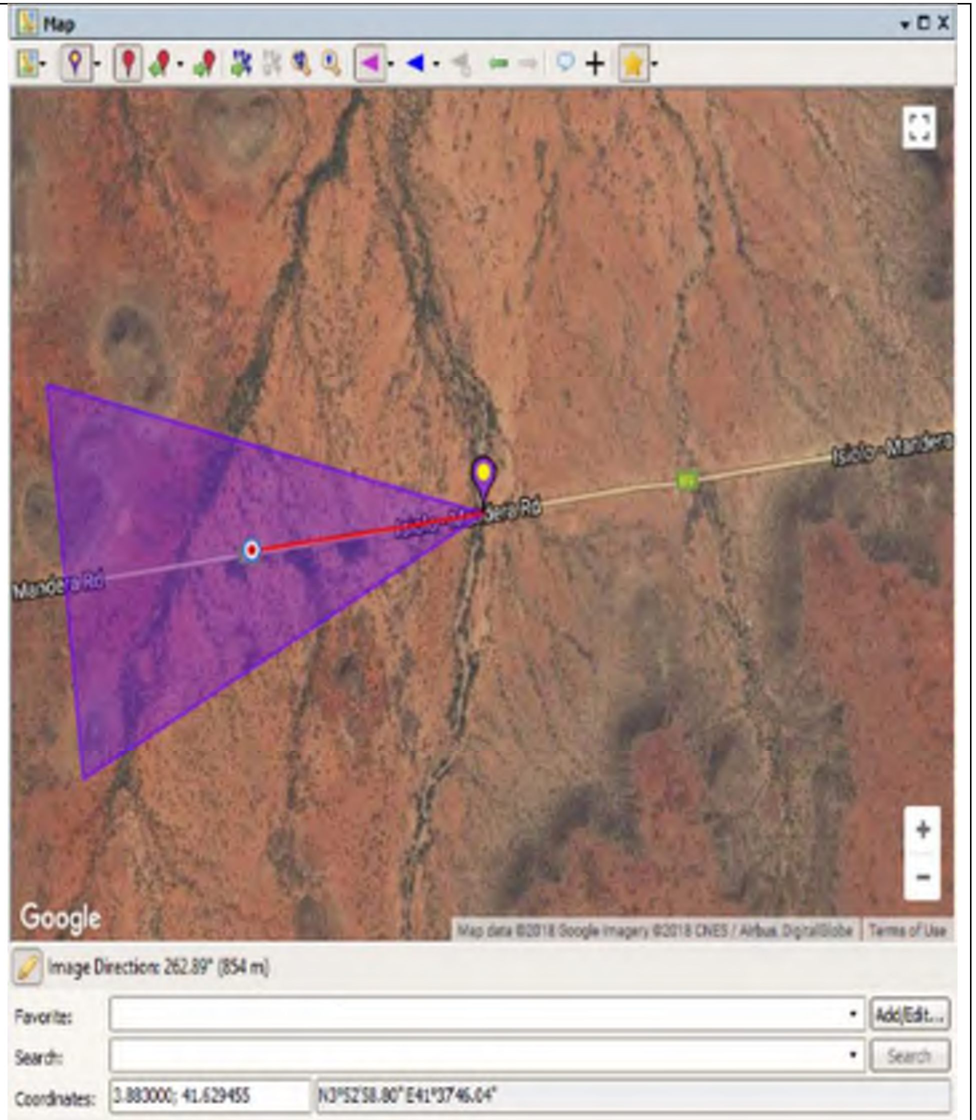


Description: drift section with lots of alluvial deposits on top and both sides of drift with photo taken in the backward direction

Coordinates: N3°52'58.80" E41°37'46.04"

Altitude: 239m

Point 96

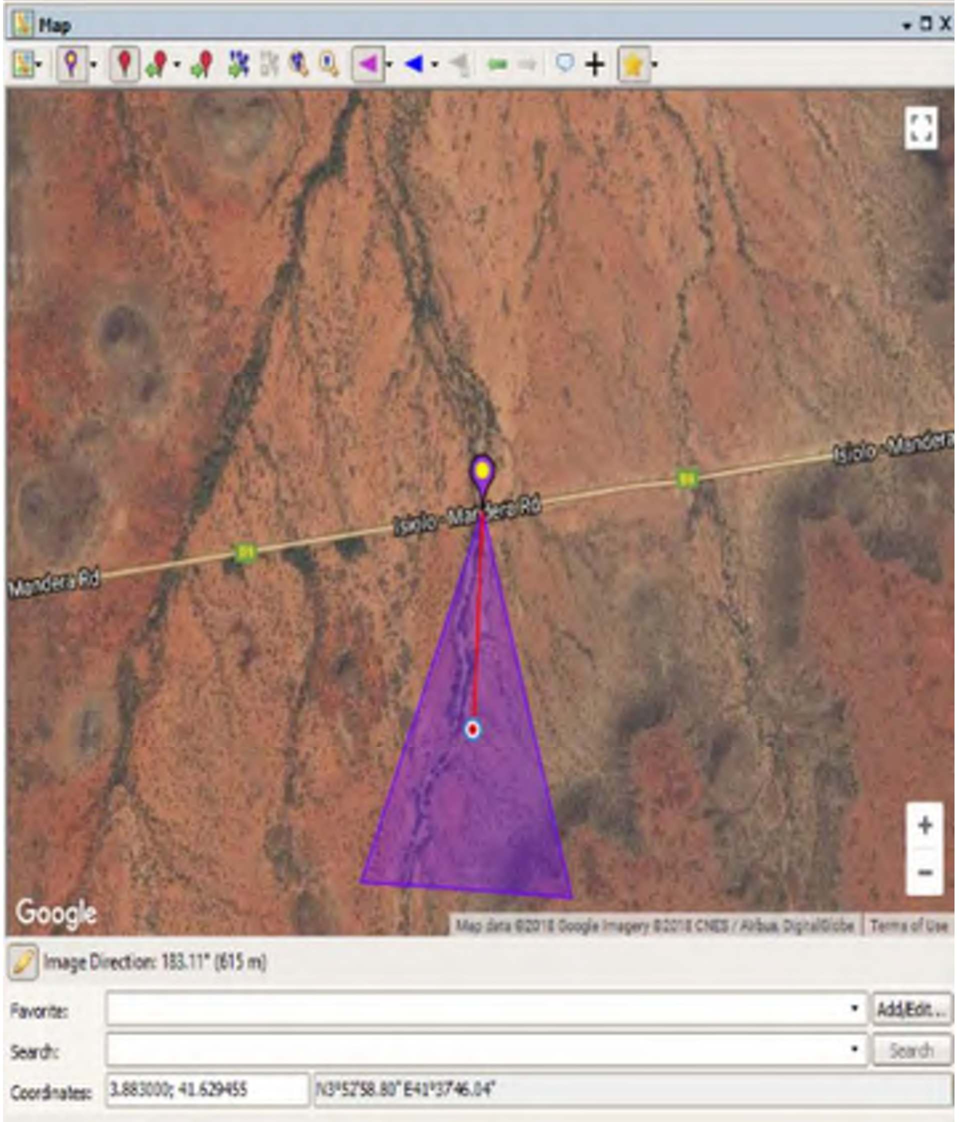


Description: drift section with lots of alluvial deposits on riverbed with photo taken in the right direction. Scouring is witnessed to depths of about 3m on the downstream.

Coordinates: N3°52'58.80" E41°37'46.04"

Altitude: 239m

Point 96

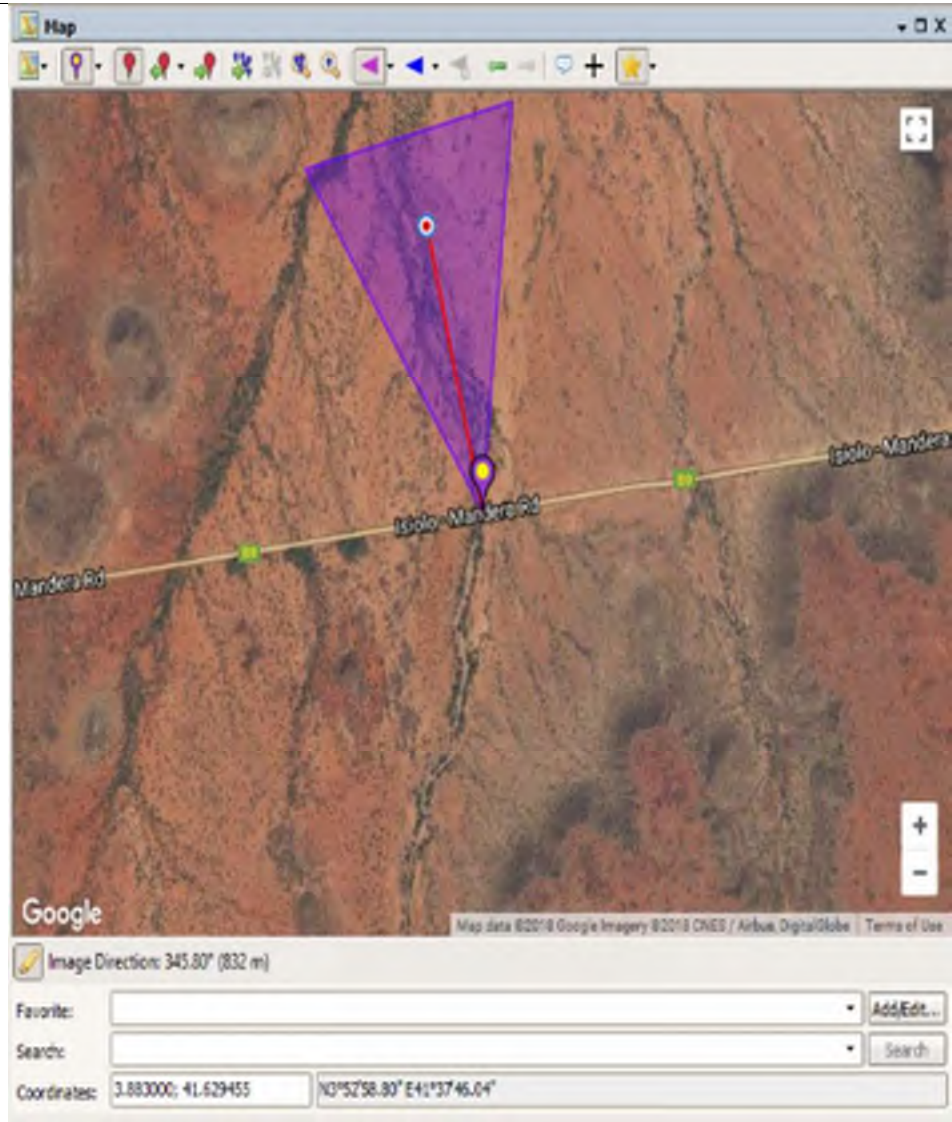


Description: Downstream of a drift section with lots of alluvial deposits on riverbed with photo taken in the left direction, showing the deeply scoured sections

Coordinates: N3°52'58.80" E41°37'46.04"

Altitude: 239m

Point 96

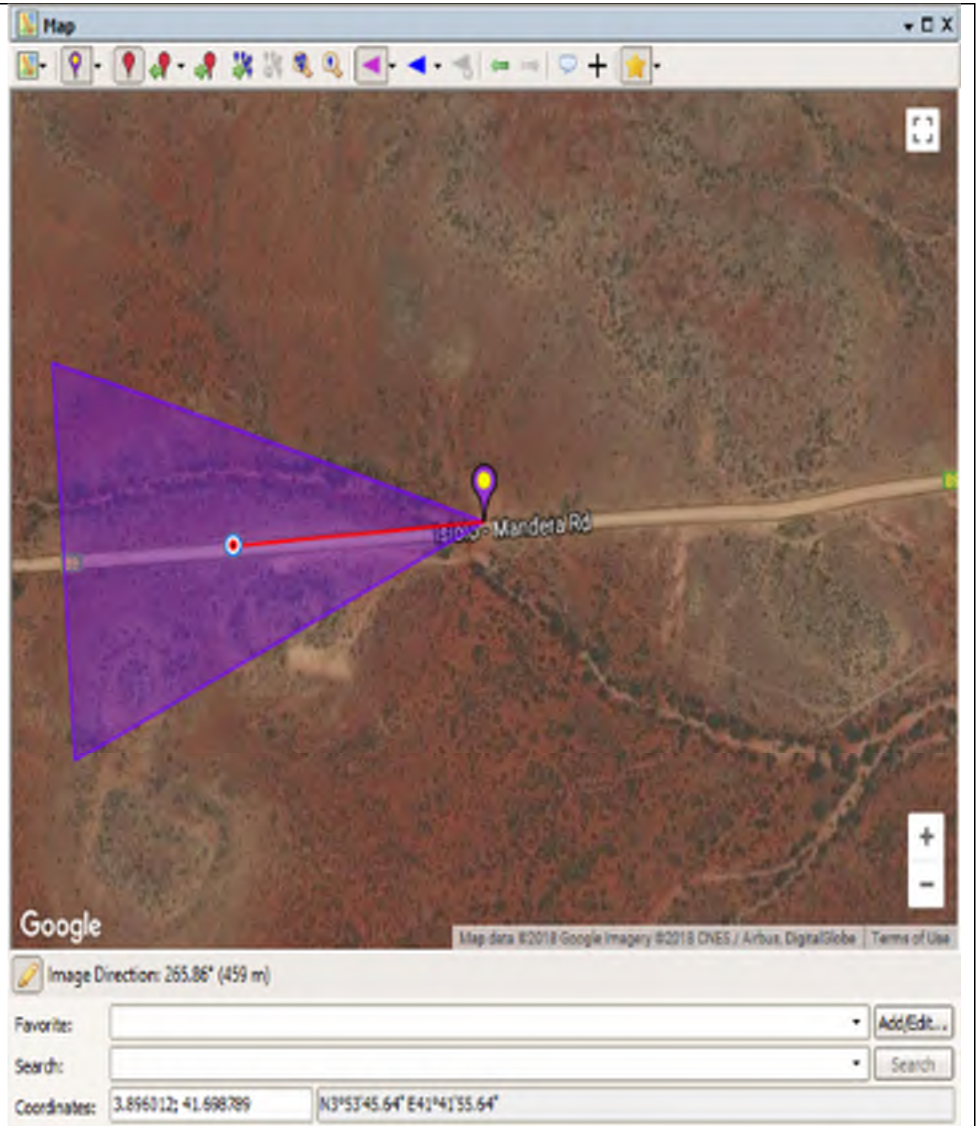


Description: Backward view of the approach road to a box culvert section 3x3m and twin pipe culverts of diameter 1200mm.

Coordinates: N3°53'45.64" E41°41'55.64"

Altitude: 258m

Point 97

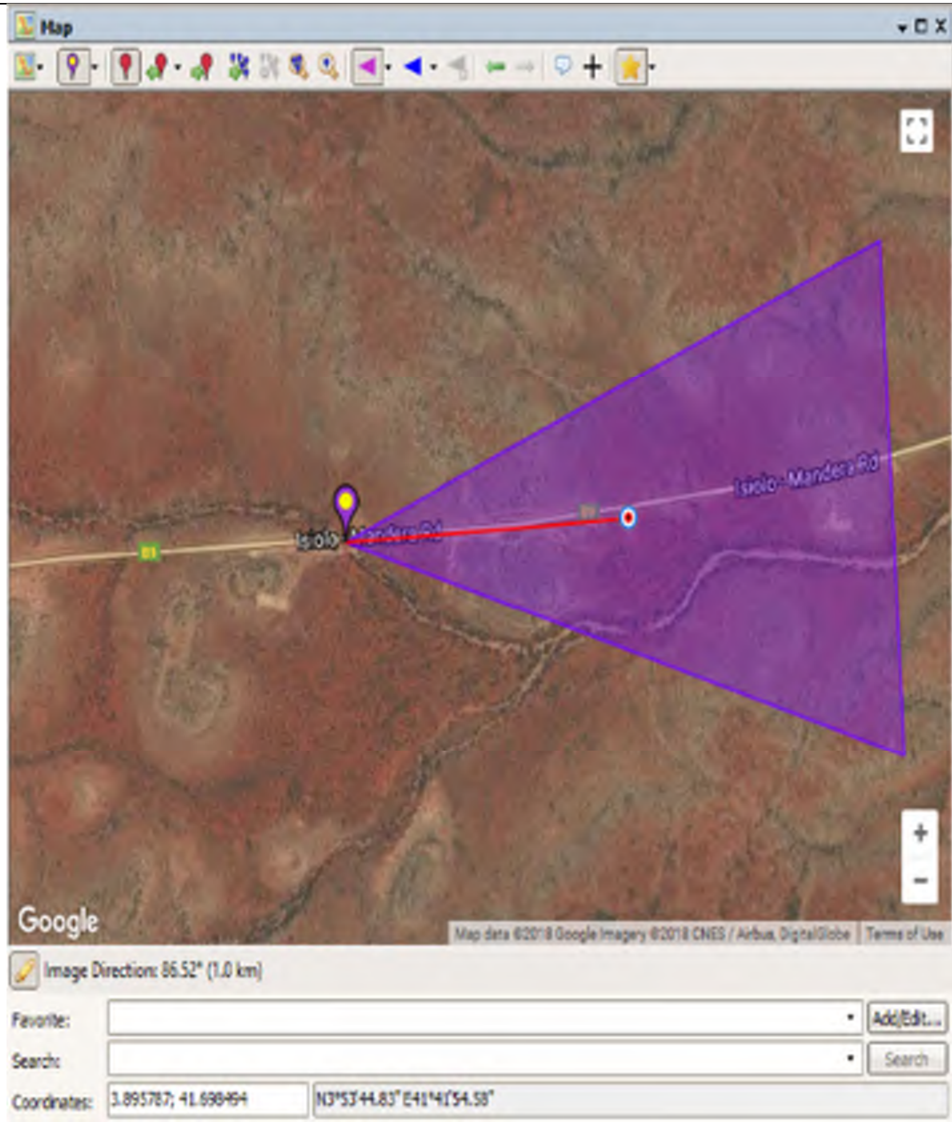


Description: Backward view of the approach road to a box culvert section 3x3m and twin pipe culverts of diameter 1200mm. The road section has been seriously scoured by the rain water on the rhs.

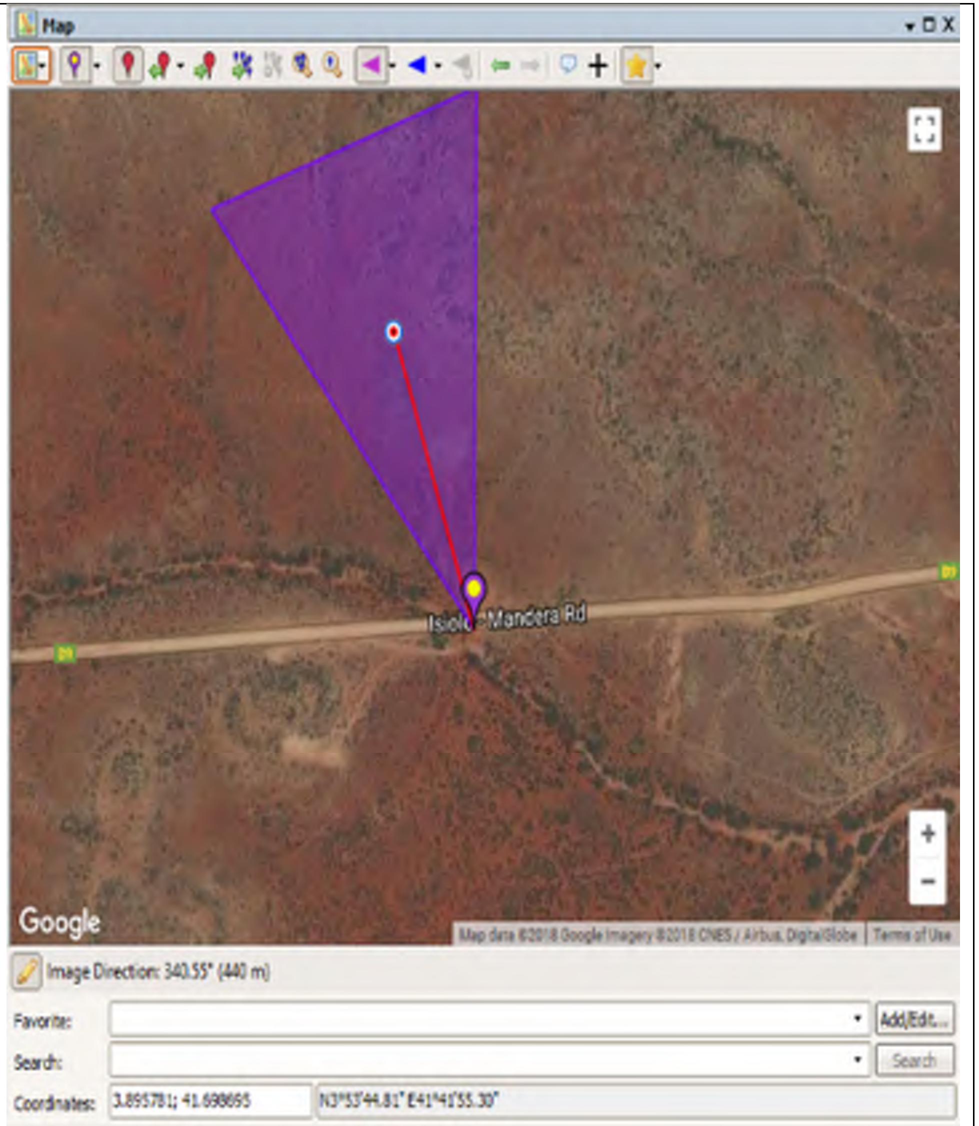
Coordinates: N3°53'44.83" E41°41'54.58"

Altitude: 243m

Point 97



Description: Rhs view of a box culvert section 3x3m and twin pipe culverts of diameter 1200mm. with gabion protection on the road side slopes.
Coordinates: N3°53'44.81" E41°41'55.30"
Altitude: 243m
Point 97

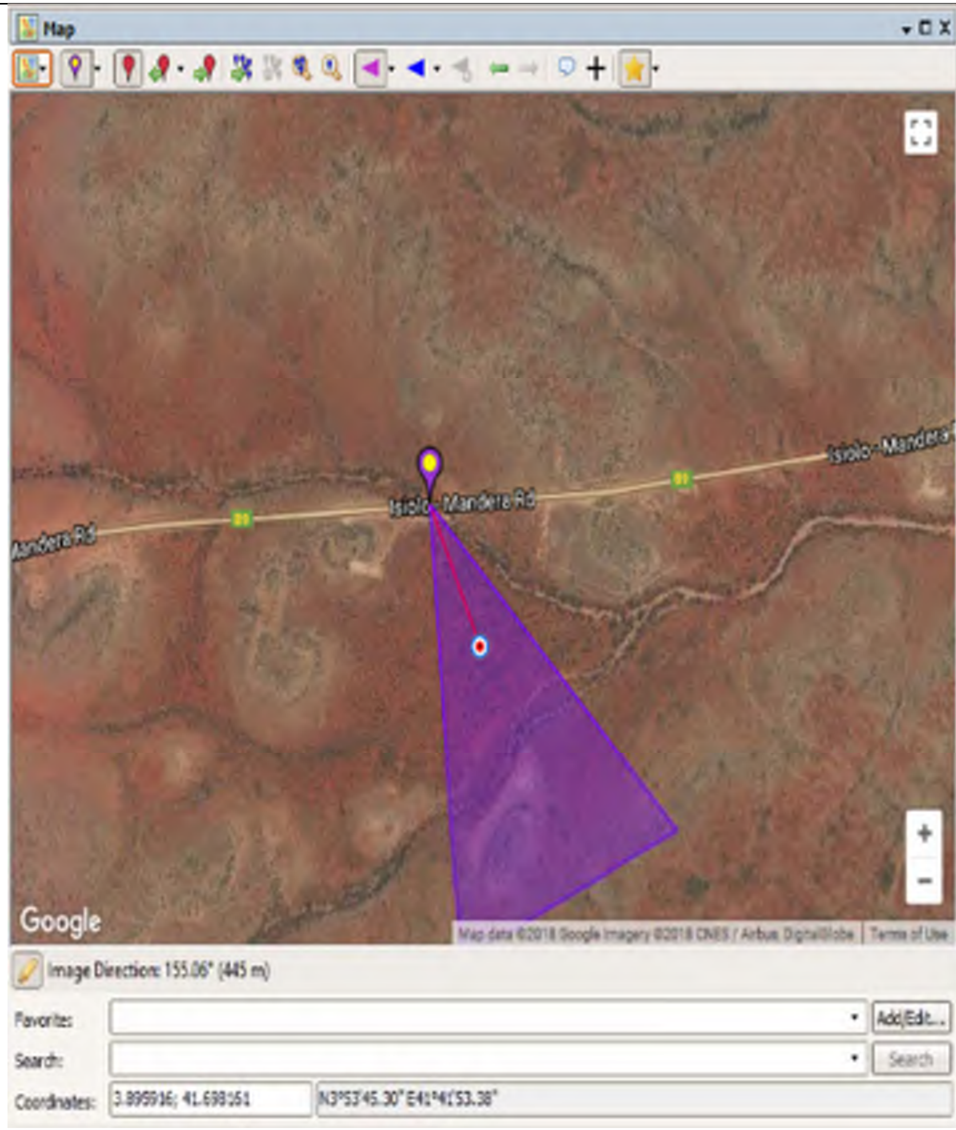


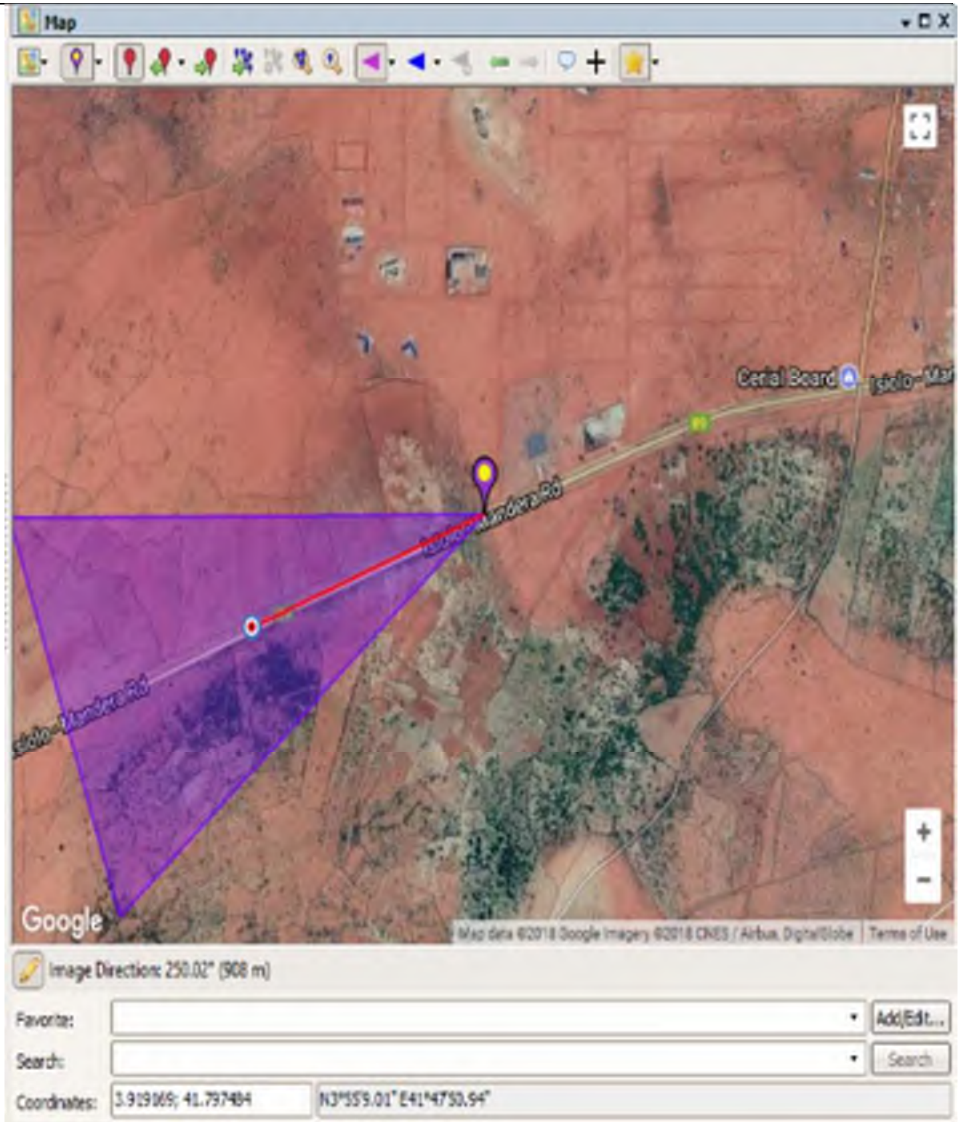
Description: Lhs view of a box culvert section 3x3m and twin pipe culverts of diameter 1200mm, with the pipe culverts being silted.

Coordinates: N3°53'45.30" E41°41'53.38"

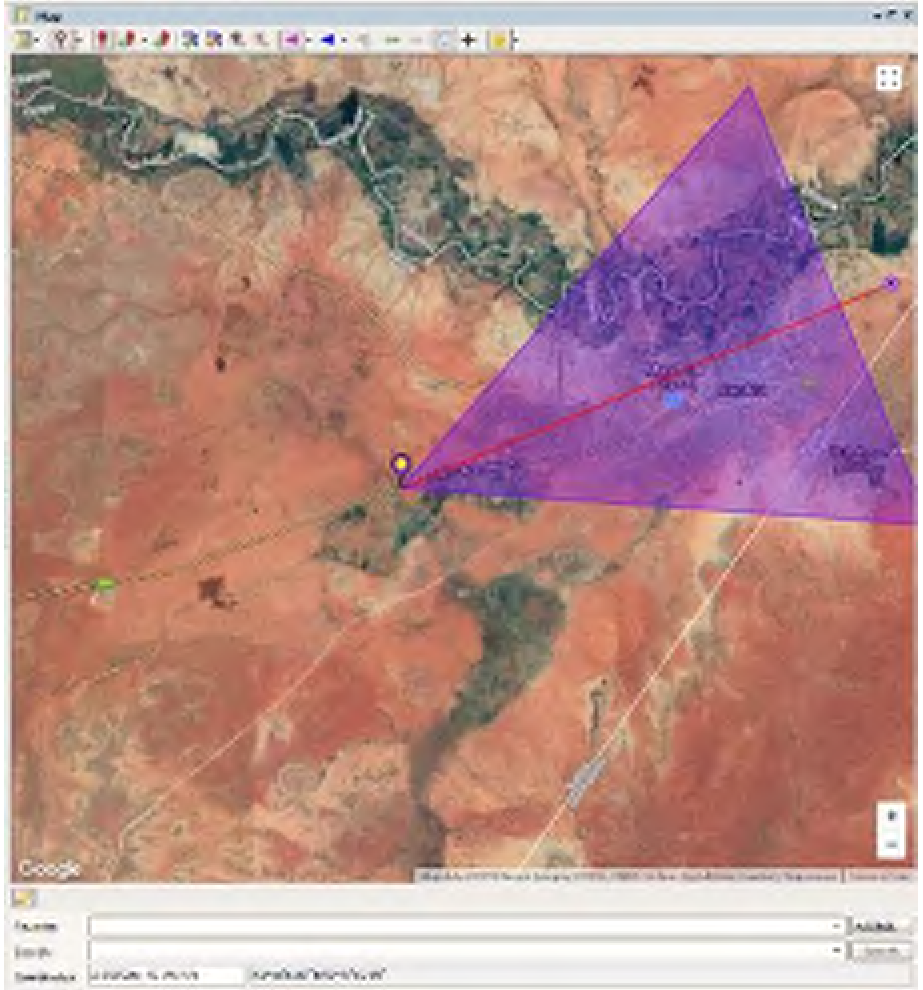
Altitude: 243m

Point 97





Description: road section cut by flood water action with no drainage structure in the area with photo taken in the back direction. The section has huge sand deposits, that cause vehicles to get stuck in the wet seasons.
Coordinates: N3°55'9.01" E41°47'50.94"
Altitude: 205m
Point 98



Description: Beginning of the tarmac road at Mandera town at about 7km from Mandera town, with photo taken in the forward direction

Coordinates: N3°55'8.89" E41°47'51.99"

Altitude: 224.8m

Point 99

TECHNICAL ASSISTANCE TO INCREASE CLIMATE RESILIENCE OF KENYAN NATIONAL ROAD NETWORK PROJECT,

MINUTES OF MEETING WITH MAINTENANCE TEAMS HELD ON 10TH APRIL 2018, IN THE BOARDROOM OF KENHA UPPER EASTERN REGION OFFICES - ISIOLO.

The meeting was called to order at 3:00 PM.

Present

1.	Eng. Patrick Kibiti	Assistant Regional Director, Upper Eastern – KeNHA.
2.	Eng. Stephen Ndinika	HOD Transport - Norken
3.	Eng. Sylvia Njane	Highways Engineer - Norken
4.	Ebby Osore	Site Inspector Upper Eastern - KeNHA

Agenda

The meeting adopted the agenda as follows:-

1. Introduction of the project
2. Hazards inherent along the NETIP corridor.
3. Identified Hazard areas
4. Security Along the NETIP Corridor
5. A.O.B

MINUTE	Discussion /Action/Responsibility
MIN 1/1/2018 **Introduction of The Project**	• Eng. Kibiti opened the meeting by requesting the members to introduce themselves. • Eng. Ndinika then gave an introduction indicating that Norken was a sub - consultant for COWI Denmark, on a project for the Technical Assistance to increase climate resilience for Kenyan National road Network. The objective of the assignment is to inform the detailed design of proposed improvements along the corridor to address natural hazards and/or climate related risks. • He noted that the country has been losing valuable infrastructure owing to unforeseen harsh climatic conditions, largely owing to the climate change being experienced globally. • This problem is mostly dominant in the arid and semi-arid areas of Kenya where, more oftenly than not, you have only one transportation corridor. • The World Bank supported project on the NETIP corridor would thus be used as a pilot project, to investigate inherent hazards due to climate conditions, and after consultations with the various stakeholders, develop a methodology for assessing vulnerability of the national highway corridors to natural hazards or projected climate related risks. Eventually the procedure will then be roll out to the rest of the network with a view of increasing the network climate resilience.

MINUTE	Discussion /Action/Responsibility
	• Eng. Kibiti commented that if the project is successful it would highly improve on the design life of the roads especially in the Arid and Semi – Arid areas.
MIN. 2/1/2018 Inherent Hazards along the NETIP Corridor;	• Eng. Ndinika inquired on some of the hazards identified on the NETIP corridor. • The Field team explained that they are mandated to carry out the Annual Road Inventory and Condition Survey, for the section of the NETIP corridor within its jurisdiction, which extends up to Habaswein. It is during this inspections that bottlenecks and damage due to climatic factors is identified. • The main problems observed on the corridor include: ✓ Washout due to flush floods during the rainly season especially the modogashe area – it is impassable during rains ✓ There are a few sections of black cotton soil which are also impassable during rains ✓ along corridor there are sections of mostly sandy soils, and these causes' vehicles to get stuck especially during wet seasons. This also occurs on the dry river beds (laga) without structures. ✓ There are also sections of rock outcrops which are at times difficult to navigate. • Eng Ndinika also inquired about sand storms /movement in the area. • The team mentioned that the areas of North Horr, (not within the NETIP corridor) experienced significant sand movement.
MIN.3/1/2018 Security and Logistics during the site visit.	• Eng. Kibiti mentioned that, for all site visits suitable vehicles to be used were the Land cruisers because of the rains to avoid being stuck. ***Action - Norken*** • He also explained that before any site visit, the security personnel are to be informed in order to furnish the team with information on security situation along the corridor. The County Commissioner would also determine the number of security personnel to be deployed during the site visit, depending on the security situation at that time. • During the actual site visit along the NETIP corridor, the security personnel together with the regional Site Inspector shall have to be exchanged at Modogashe, since the team shall be crossing to a different area of jurisdiction i.e from the Upper Eastern region to the North Eastern region. • Eng. Kibiti mentioned that during site inspections for ARICS, their staff usually take 1 day from Isiolo to Garbatula and another day from Garbatula to Modogashe. Within this section, the main area of security concern is usually between km 140 and km 160, at a region called El Dera.

MINUTE	Discussion /Action/Responsibility
	• The Assistant Regional Director requested the staff from Norken to inform them in advance of the scheduled site visit, in order for them to get information on the security situation along the corridor at that particular time. ***Action – Eng S Njane***
MIN.4/1/2018 Annual Road Condition and Inventory Survey Data	• Ms Osare mentioned that an ARIC survey had been carried out for the section of the NETIP corridor from Isiolo to Modogashe, for the year 2017. • From the data collected, the main hazard identified along the corridor were flush floods especially at Modogashe area, and also the soil type. Since most areas have sandy soils that causes vehicles to get stuck during the wet seasons. • Also since the area has a flat terrain, there are sections that experience flooding. • Eng. Ndinika noted that the flooding areas would require, raising the pavement and also including balancing culverts during design, in order to prevent the damming effect of the raised road. • Eng. Kibiti gave a hard copy of the ARICS raw data for the year 2017, to be used together with the previously identified hazard areas during the site visit.
MIN. 5/1/2018 A.O.B	• There being no other business, the meeting was adjourned at 4.30pm

Confirmed By:

Chairperson:………………………………. **Date:……………………………**

Secretary:………………………………. **Date:……………………………..**

TECHNICAL ASSISTANCE TO INCREASE CLIMATE RESILIENCE OF KENYAN NATIONAL ROAD NETWORK PROJECT,

MINUTES OF MEETING WITH MAINTENANCE TEAMS HELD ON 30TH MAY 2018, AT HABASWEIN.

The meeting was called to order at 2:00 PM.

Present

5. Eng. Sylvia Njane — Highways Engineer – Norken
6. Victor Wamere — Assistant Engineer – Norken.
7. Mohammed Edow — Site Inspector North Eastern – KeNHA
8. Abduba Mohammed — Site Inspector Upper Eastern – KeNHA
9. Mohammed Diba — Senior Supretendant - Habaswein

Absent with Apology.

1. Eng Eric Wambua — Assistant Director – North Eastern Region.

Agenda

The meeting adopted the agenda as follows:-

6. Introduction of the project
7. Hazards inherent along the NETIP corridor.
8. Identified Hazard areas
9. Security Along the NETIP Corridor
10. A.O.B

MINUTE	Discussions/Actions/Resposibility
MIN 1/2/2018 **Introduction of The Project**	• Eng. Sylvia Njane opened the meeting by requesting the members to introduce themselves. • She then gave an introduction indicating that Norken was a sub - consultant for COWI Denmark, on a project for the Technical Assistance to increase climate resilience for Kenyan National road Network. The objective of the assignment is to inform the detailed design of proposed improvements along the corridor to address natural hazards and/or climate related risks. • She then gave a brief of the project indicating that the country has been losing valuable infrastructure owing to unforeseen harsh climatic conditions, largely owing to the climate change being experienced globally. This problem is mostly dominant in the arid and semi-arid areas of Kenya. • The World Bank supported project on the NETIP corridor would thus be used as a pilot project, to investigate inherent hazards due to climate conditions, and after consultations with the various stakeholders, develop a methodology for assessing vulnerability of the national highway corridors to natural hazards or projected climate related risks. Eventually the procedure will then be roll out to the rest of the network with a view of increasing the network climate resilience.
MIN. 2/2/2018 Inherent Hazards along the NETIP Corridor;	• Mr Edow informed the team that since the onset of the heavy rains, the section from Habaswein heading to Mandera had been seriously affected, after the three drifts at Habaswein were washed out, meaning no vehicle could be able to proceed to Wajir and Mandera, except through Garissa, which was about 200km diversion. The contractor doing maintenance in this section had been

MINUTE	Discussions/Actions/Resposibility
	instructed to take emergency measures to repair the drift, or at least make it passable by putting rock fill. • Meanwhile, the Norken team had to walk through the water to the other side in order to continue with the site visit. • He also mentioned that from Wajir to Mandera, there were three contractors contracted to improve the gravel road to bitumen standards, with the funding coming from the ministry of defence. This had been necessitated by the increased incidences of land mines planted along the road by the Al Shabaab militant group. Construction was ongoing from Rhamu towards Elwak, but work had not started on the section between Wajir and Elwak due to security reasons, since the section is about 8km from the Kenya Somali border. • He also mentioned that the section from Habaswein to Wajir had a lot of sand deposit on the road due to the rain water flowing on the road, which causes vehicles to get stuck in the wet seasons.
MIN.3/2/2018 Security and Logistics during the site visit.	• Mr Edow explained that before the site visit, the security personnel are to be informed in order to furnish the team with information on security situation along the corridor. The County Commissioner would also determine the number of security personnel to be deployed during the site visit, depending on the security situation at that time. • For the section between Wajir and Elwak, he advised that the stops should be as brief as possible, and for the team to plan the work in a way that they will have reached Elwak by 3pm in the afternoon, due to the higher security risk along this section. • The Senior Supretendant advised that on reaching Wajir, the team should make a courtesy call to the Rapid Deployment unit section, to get security updates on the section between Wajir and Elwak. In the case of any alert, the team should delay the visit, until they get clearance from the security personnel. In case of any incidence, the team is to contact the RDU at Kutulo, then the base commander at Habaswein. ***Action Eng S Njane***
MIN.4/2/2018 Annual Road Condition and Inventory Survey Data	• Mr. Edow mentioned that an ARIC survey had been carried out for the section of the NETIP corridor from Modogashe to Wajir, for the year 2017. • From the data collected, the main hazard identified along the corridor were flush floods, and also the soil type. Since most areas have sandy soils that causes vehicles to get stuck during the wet seasons. • Mr. Edow reported that Eng Wambua had sent a soft copy of the ARICS data for the year 2017, to be used together with the previously identified hazard areas during the site visit.
MIN. 5/2/2018 A.O.B	• There being no other business, the meeting was adjourned at 3.00pm

Confirmed By:

Chairperson:……………………………….. Date:……………………………

Secretary:……………………………….. Date:…………………………….