Dunoon Surface Water Management Plan -Options Appraisal Black Park

Final Report

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P01 09/08/19	-	Grant Whyte
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Contract

This report describes work commissioned by Grant Whyte on behalf of Argyll & Bute Council by Purchase Order number AB315359. Argyll & Bute Council's representative for the contract was Grant Whyte. Steven Thomson of JBA Consulting carried out this work.

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Purpose

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1 Introduction

1.1 Site location

Black Park in Dunoon (previously identified as Ash Park in the Dunoon SWMP 2019) is located between Argyll Street, Argyll Road and Park Road. The park features an athletics stadium, rugby pitch, all-weather football facilities and large gravel car parking area to the south. The topography generally falls to the southwest with all rainfall falling within the catchment flowing towards this point. As such, the overland flow in the carpark and south west of the park is substantial.

1.2 Objectives of the study

The objective of this options appraisal study is to:

Undertake a hydrological assessment of the contributing catchments.

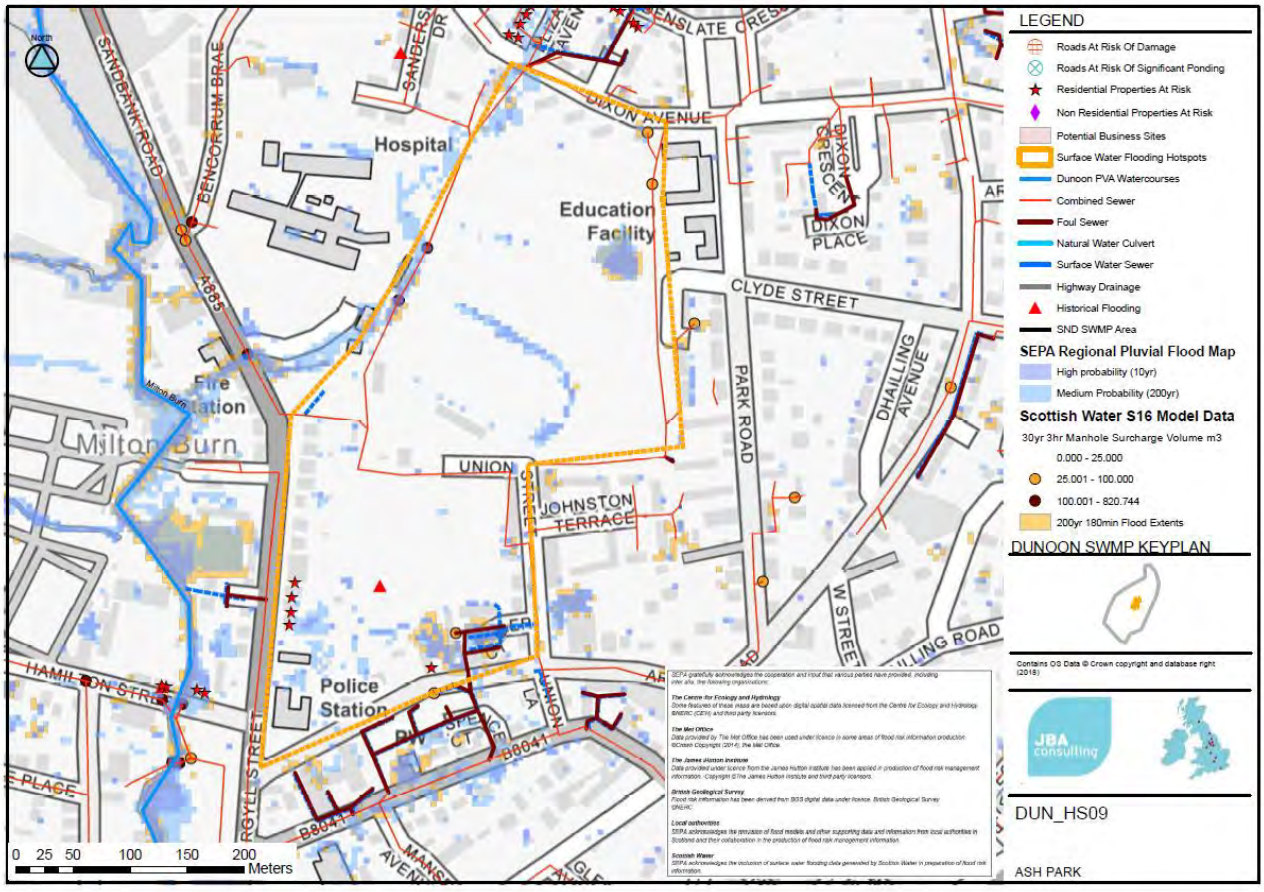
Undertake a hydraulic model to understand overland flow paths and peak flows reaching the south west corner.

Develop options that can mitigate flood risk to the vulnerable properties in the area.

Undertake a cost benefit analysis of the proposed options.

Present a preferred option and suggest next steps.

Figure 1-1: Black Park Hotspot 09 from Dunoon Surface Water Management Plan (SWMP) 2019



2 Existing conditions

2.1 Site visit

On Tuesday 30th January 2019 Steven Thomson and Rene Dobson of JBA Consulting undertook site walkover surveys of 3 surface water flooding hotspots in the Dunoon area and 1 in Kilcreggan. The sites that were visited are those that had been highlighted in the Dunoon and Kilcreggan 2018/19 SWMPs as high priority (2018s0549_Dunoon_SWMP_Report, JBA Consulting, 2019).

2.2 Existing Drainage Infrastructure

The overland flow paths are currently to the south west corner of the park and subsequently into the rear gardens of the neighbouring properties. Flows which reach the southern boundary of the site enter a drainage ditch which falls towards a pumping station in the south east corner of the site. The drainage ditch has little to no flow and is full of debris and detritus. The pumping station itself is believed to have been installed when the Miller Court development was constructed. Prior to this, local residents believed it entered the combined sewer at a headwall further east.

The pumping station itself was not shown on any drainage drawings and has only come to light due to recent flooding concerns in the area. Argyll and Bute Council are understood to be responsible for the pumping station. The capacity of the pumping station is unknown however, from the site visit it was evident that it is substantially undersized. According to local accounts, the neighbouring resident to the pump station has been maintaining the pump station himself for years as when the pump fails much of his garden is inundated. He noted that it is in a very poor condition and frequently breaks down. The resident had also raised the ground level at the pump station and his garden using single sized stone to allow access to the pumping station during inclement weather. The pumping station is believed to be connected to the combined sewer running through the gardens of 27/28 Miller Court..

Figure 2-1: Drainage ditch at the southern boundary of the park

Figure 2-2: Drainage ditch adjacent to pumping station with improvised screen

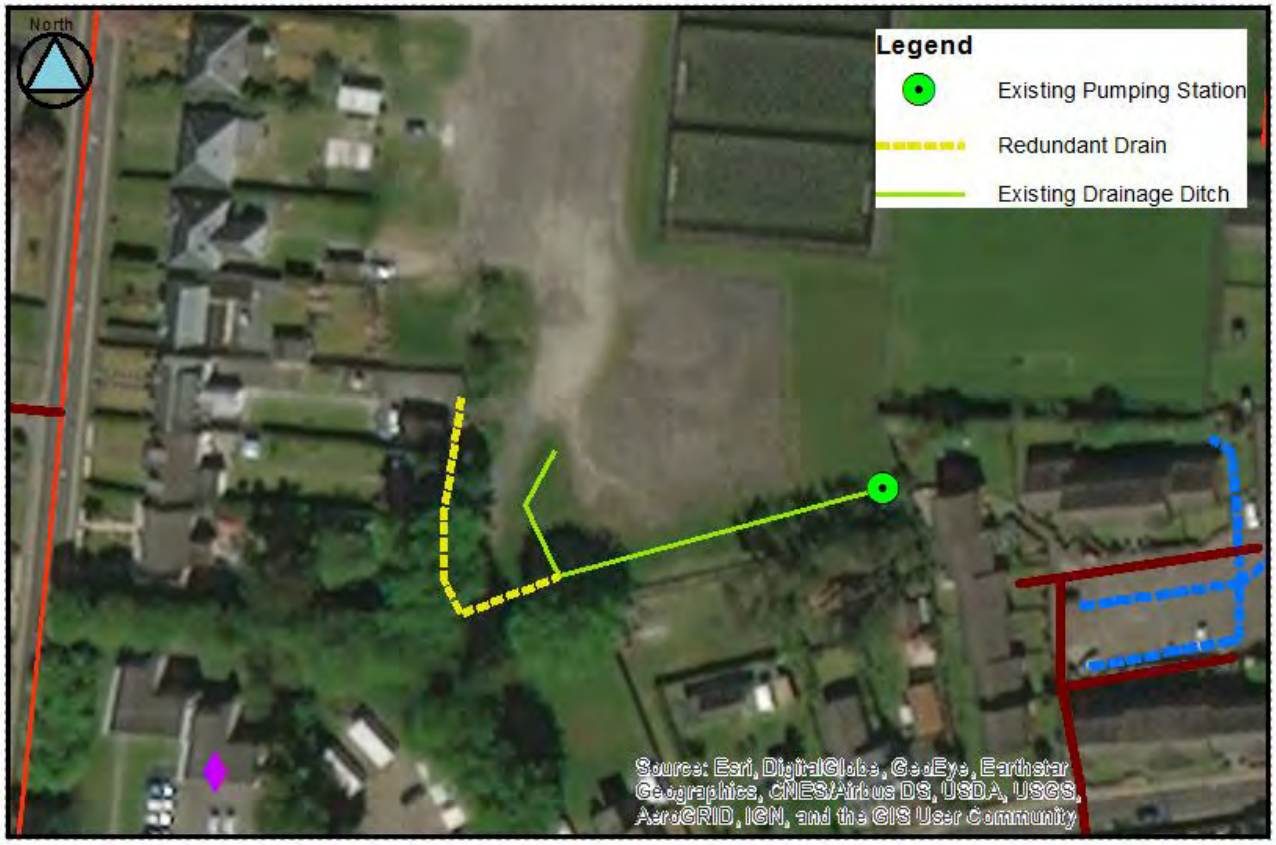
Figure 2-3: Pumping Station control and access point

Figure 2-4: Pumping Station with raised stone working area

Figure 2-5: Pump (note small diameter of outgoing white pipe)

Local residents also highlighted that there used to be an open channel/filtration trench system on the western boundary of the park. However, over the years this has been damaged, built over and has not been maintained hence, there is very little remaining evidence of this feature on site.

Figure 2-6: Existing drainage layout



2.3 Existing flood risk

The existing flood risk to residents was unclear before the site visit as the issues had not been reported for years. During the site visit, residents told of how flood water frequently entered their gardens however, there had been no internal flooding to date to the knowledge of the residents present. The property adjacent to the pumping station has raised the lower half of his back garden using permeable stone as it is permanently waterlogged and unusable.

The frequency of the flooding is unclear but is thought to be up to several occurrences per month based on residents comments.

Figure 2-7: Overland flow path to south west corner visible during site walkover

2.4 Site surveys (Topography, drainage etc)

There are no surveys available for this area.

3 Hydrology

3.1 Background and Scope

Black Park, Dunoon (NGR: NS 17515 77853) is currently utilised as a sporting facility. The site is comprised of an athletics stadium, rugby pitch, all-weather football facilities and a large gravel carparking area to the southern site boundary.

The primary mechanism of flooding at Black Park is overland surface water flow from the upper reaches of the catchment, originating from the north. Overland flow generated both on-site and upland of the site follow the natural topographic decline to the south west, allowing surface water to collate to the south of the site and direct pluvial flows off site and into neighbouring residential development and gardens. Residents have reported flood depths in rear gardens up to 0.3m deep several times a month.

The purpose of this study is to assess the overland pluvial flow paths through Black Park and offsite at the south-western corner using an appropriate 2D hydraulic modelling. The return periods required are the 1-in-2 year, 1-in-5 year, 1-in-10 year, 1-in-30 year, 1-in-50 year, 1-in-100 year, 1-in-200 year and 1-in-200 year + CC (climate change) events. In the context of this review climate change uplifts have been applied at 20% in accordance with SEPA's Technical Flood Risk Guidance for Stakeholders, Version 12, 2019.

Figure 3-1: Study Location and significant features

3.2 Methodology

3.2.1 Hydraulic modelling

To assess the flood risk and the overland flow paths within Black Park, a surface water hydraulic model was constructed in Infoworks ICM to assess flood risk from pluvial sources both to and from the site. ICM allows for a single model that can incorporate urban and river catchments and enables the hydraulics of both to be assessed in a single model. It is considered the most suitable software where flood risk to a site may arise from multiple sources. The inputs to ICM assessing surface water flood risk are a DTM (Digital Terrain Model) and a design rainfall event.

3.2.2 Digital Terrain Model and 2D mesh

To assess surface water flood risk, the contributing catchment must be included in the model, to determine flow entering the site. Therefore, a DTM was created by combining freely available elevation-based data and LiDAR data, obtained from the Scottish Remote Sensing Portal (SRSP). ICM builds a mesh of triangular elements with varying cell size base on the terrain which allows for flat areas to be modelled with large elements and undulating areas to be represented with small elements. The mesh parameters were set so that the minimum element size and maximum mesh triangle area set to 1m² for the whole of the study area. Boundary Points were set to Normal Condition and the Rainfall Percentage value was changed from the default of 100% to 75% to represent the surface water which will be soaked up by permeable ground.

Built structures utilised for this study were derived by using OS Open Map Local data to create a shapefile of buildings located within the 2D mesh zone. Buildings were imported into the model as porous polygons with a height of 300mm and a porosity of 30%. The roads were exported as roughness zones and were given a roughness co-efficient of 0.005.

3.2.3 Design Rainfall Events

Rainfall estimates were generated using the FEH with Depth-Duration-Frequency (DDF) Modelling used to generate baseline rainfall. Catchment Descriptors were obtained for the site from the FEH Web Service in February 2019. 1 km² DDF parameters are included within the FEH Web Service catchment descriptors and were used to inform the InfoWorks FEH rainfall generator available within the ICM software (DDF parameters are provided in Table 2-1). To simulate surface water flooding across the area of interest, the hydraulic model uses a Direct Rainfall approach which consists of applying a rainfall hyetograph representative of a storm event to every individual element within the 2D surface model (across the 2D zone). The design events modelled are listed in Section 1.

The base model was run for a number of storm durations to determine the critical storm duration by determining which storm event achieved the highest peak water level, and thereby the greatest volume. Following a review of the peak flows, it was established that the 8-hour (480 minute) duration event is the critical storm duration for the catchment model (Table 2-2). Although the 8 hour event is the critical event it is worth noting that the resultant depths are fairly consistent for the majority of storm durations over 3 hours. The model simulation time was set to 12 hours to show the extent of each return period and to allow water in high topographical areas to flow throughout the model, giving more accurate results of the extent of flooding.

Table 3-1: 1 km² Depth Duration Frequency (DDF) parameters

DDF Parameter	Value
C	-0.019
D1	0.509
D2	0.409
D3	0.47
E	0.259
F	2.394

Table 3-2: Critical Storm Duration Results

Scenario	Duration (min)	Depth (m)
Base	30	0.518
Base	60	0.549
Base	90	0.562
Base	120	0.567
Base	180	0.574
Base	240	0.579
Base	300	0.581
Base	360	0.583
Base	420	0.584
Base	480	0.584
Base	540	0.584
Base	600	0.584
Base	720	0.583
Base	840	0.581
Base	960	0.579
Base	1080	0.578
Base	1200	0.576
Base	1320	0.575
Base	1440	0.574

3.3 Hydraulic Model results.

3.3.1 Flood Outlines

Modelled flood depths were capped to a minimum depth of 0.01m, as flood depths modelled below this level are considered insignificant and unlikely to result in any significant damage within the area. Flood depths and extents for each return period were imported into ArcGIS to visually show how pluvial flooding of each design event could impact the site.

Figure 3-2: Surface water flood depths for the 1-in-30 year flood event

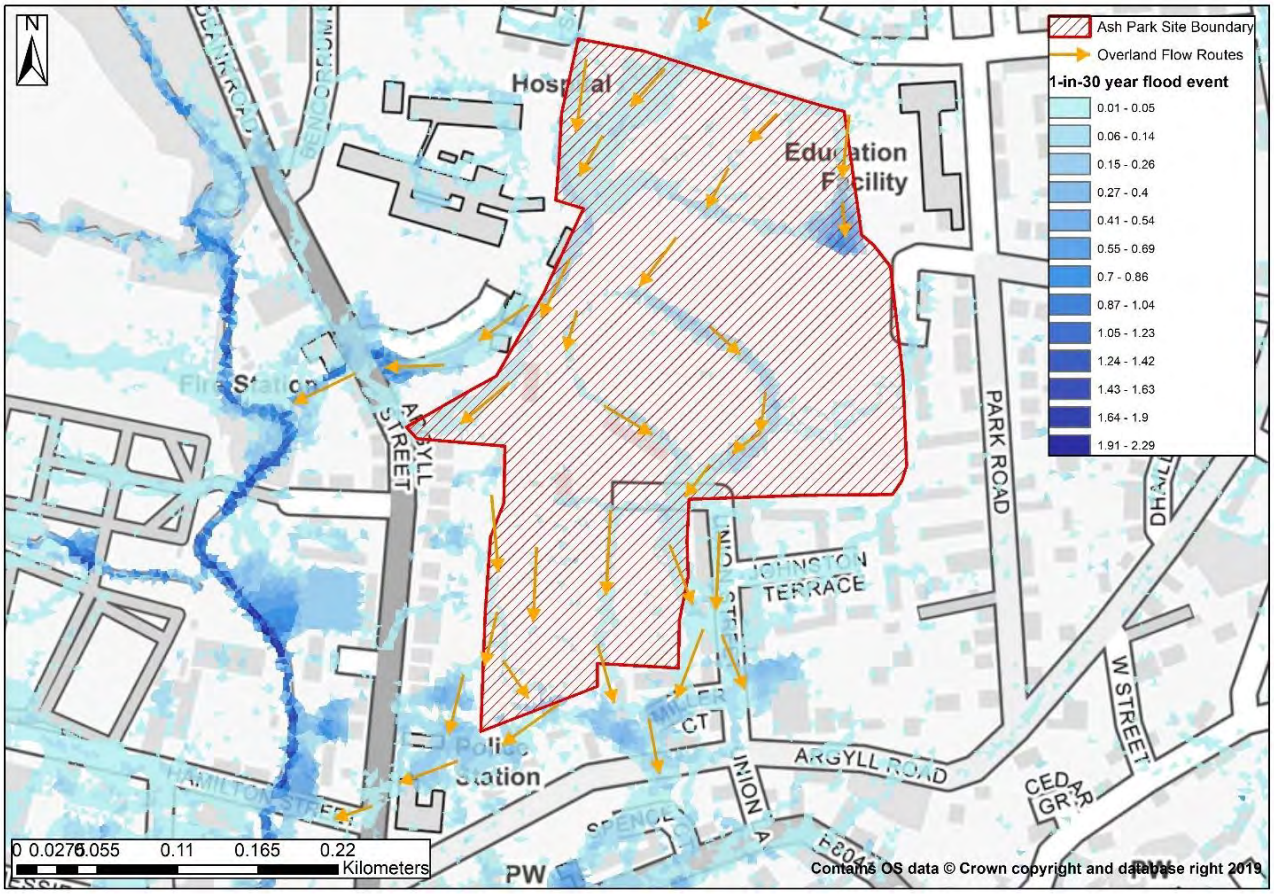
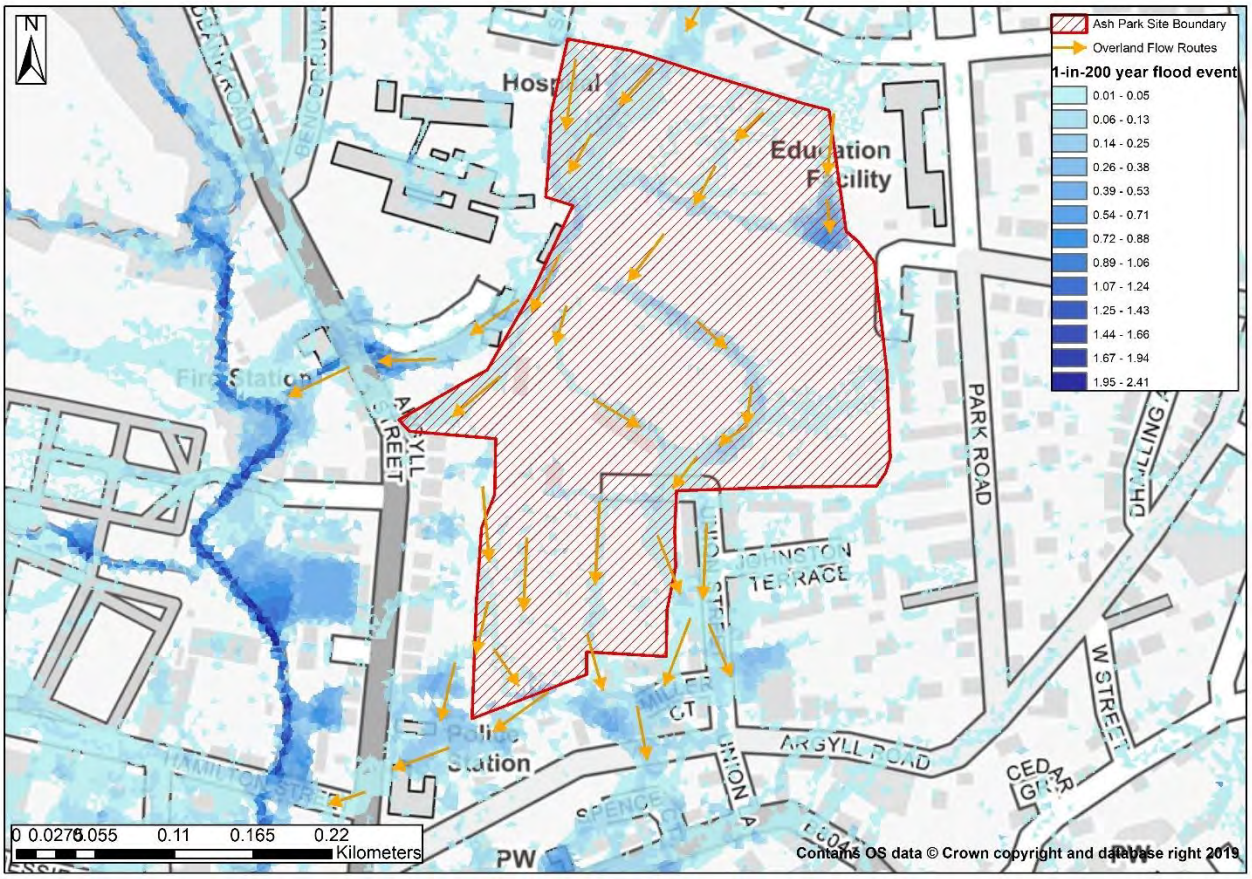


Figure 3-3: Surface water flood depths for the 1-in-200 year flood event



3.4 Flood Depths and Peak Flows

Infoworks ICM v8.5 mapping indicates the primary location of overland flow Black Park does originate from the north and is able to flow through the site in a southerly direction. Based on model results the residential properties located on Argyll Street, Argyll Road, Miller Crescent and Union Street, are considered to be at most risk of pluvial flood waters flowing off Black Park. Residential properties located at Miller Crescent and Union Street are deemed to be predominately susceptible to pluvial flooding during a 1 in 2-year flood event. It should be noted that the police station and adjacent office building to the southwest of Black Park is also at risk of pluvial flooding. It should be noted that this modelling does not account for flows being intercepted by road gullies.

Pluvial flood depths at Argyll Street, Argyll Road, Miller Crescent and Union Street are modelled to range between 0.01 and 0.4m above ground levels during a 1-in-30 year flood event however the majority of the proposed developments located within the pluvial flood extent are modelled to be at risk of depths up to 0.26m above ground levels. Pluvial flood depth range is expected to rise to between 0.01 and 0.44m above ground levels during a 1-in-200 year flood event.

Peak flows were extracted for properties located to the north and east of Dunoon police station and are listed in Table 3-3.

Table 3-3: Extracted Peak Flows

Return Periods	Peak Flows (m^3/s)
2	0.099
5	0.122
10	0.148
30	0.191
50	0.22
100	0.255
200	0.292
200+CC	0.384

Table 3-4: Predicted Storage Volumes

Return Periods	Storage Volume Required (m^3)
5	292
10	503
30	850
50	1031
100	1307
200	1609
200+CC	2319

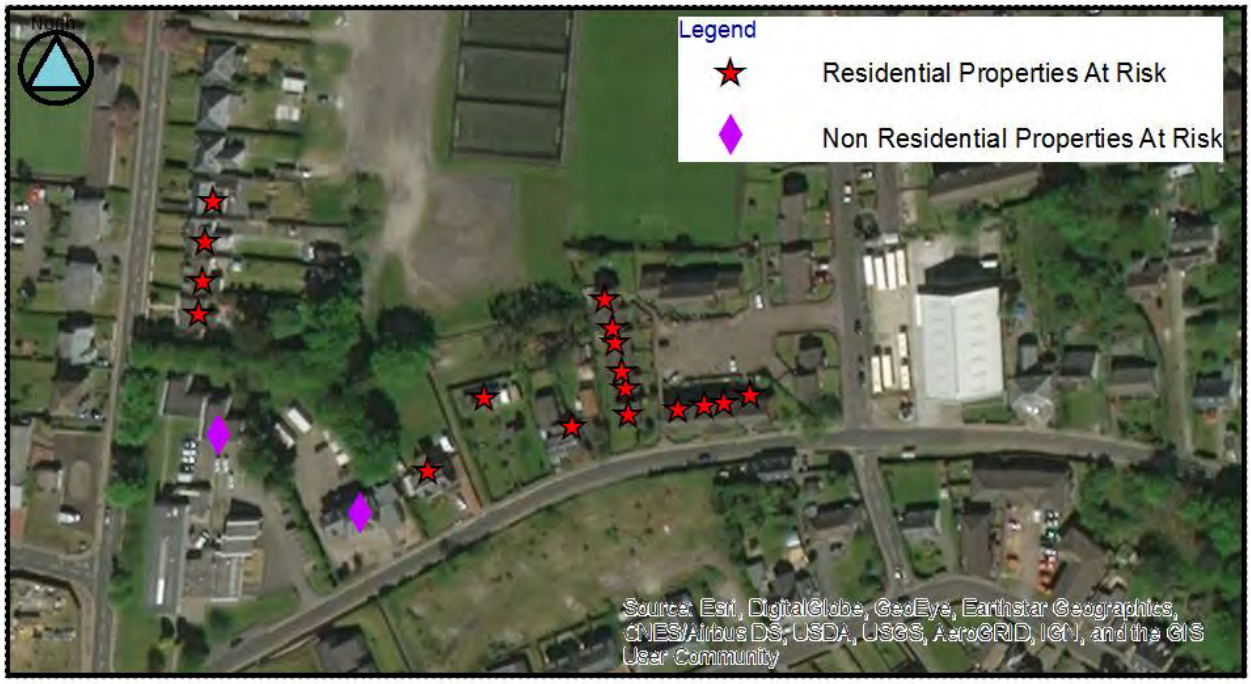
3.5 Estimated Properties at Risk

Using the knowledge gained from the site visit and the output of the 1 in 30year and 1 in 200year hydraulic model as shown in figure 3-2 and figure 3-3, the following properties are predicted to be at direct risk of flooding. This includes Dunoon Police Station and the adjacent non-residential building estimated to be No.10 Argyll Road. The flow path through Spencer Crescent and to the east of Miller Court would need to be confirmed with more in-depth modelling that took road drainage into account.

Table 3-5: Estimated properties at risk

Street Name	Residential	Non Residential
Argyll Street	4	-
Argyll Road	3	2
Miller Court	10	-
Total	17	2

Figure 3-4: Estimated properties at risk

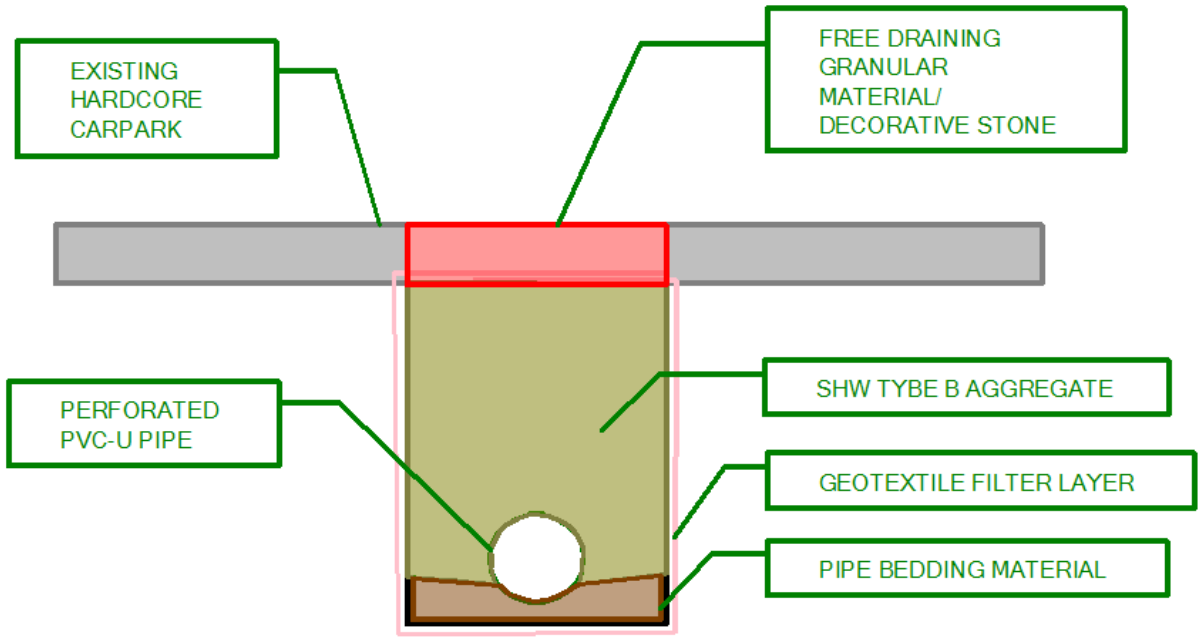


4 Options appraisal

4.1 Option 1: Filtration Trench

In order to mitigate flood risk in this area the initial objective is to capture the surface water runoff before it reaches the properties in the south west corner of the park. Filtration trenches have been identified as the preferred method for capturing the overland flow as they can be easily integrated into the existing carpark, are relatively low cost and easily maintained. Alternatives such as open filter channels/ditches/swales will require more land take and will also require bridging to maintain access to properties as well as having a greater maintenance burden.

Figure 4-1: Indicative filtration trench detail



The top layer of aggregate should be a separate colour to that of the existing car park hardcore which will help to differentiate and locate the filtration trenches however this may be difficult to maintain without hard separation.

The drainage runs will be split with an east and west run which are 124m and 92m in length respectively, both of which drain to manhole No.1. The peak flows are assumed to act uniformly across the filtration trench hence the peak flows are divided based on the length of each run i.e. East run:57% (0.22m^3/s) West run:43% (0.17m^3/s).

The proposed routes of the filtration trenches are shown in figure 4.2 below. The subsequent table shows the indicative pipe geometry details based on the available LiDAR data and the pipe sizing charts utilising the Colebrook-White formula.

Figure 4-2: Filtration trench network

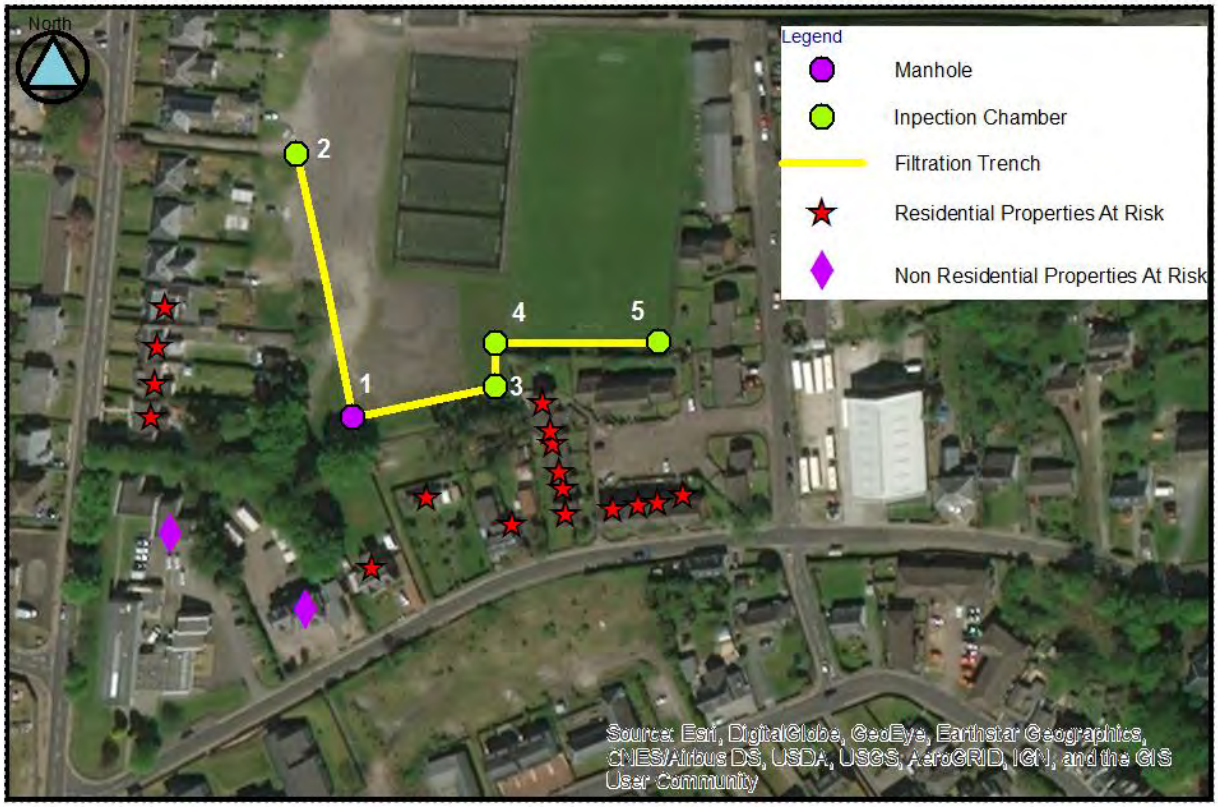


Table 4-1 Manhole details

Manhole / inspection chamber	Ground Level (mAOD)	Invert Level (mAOD)	Trench depth (m)	Cover (m)
1	16.82	14.87	1.96	1.59
2	17.84	16.67	1.18	0.8
3	16.90	15.37	1.54	1.17
4	17.25	15.55	1.71	1.34
5	17.28	16.11	1.18	0.8

Table 4-2: Pipe details

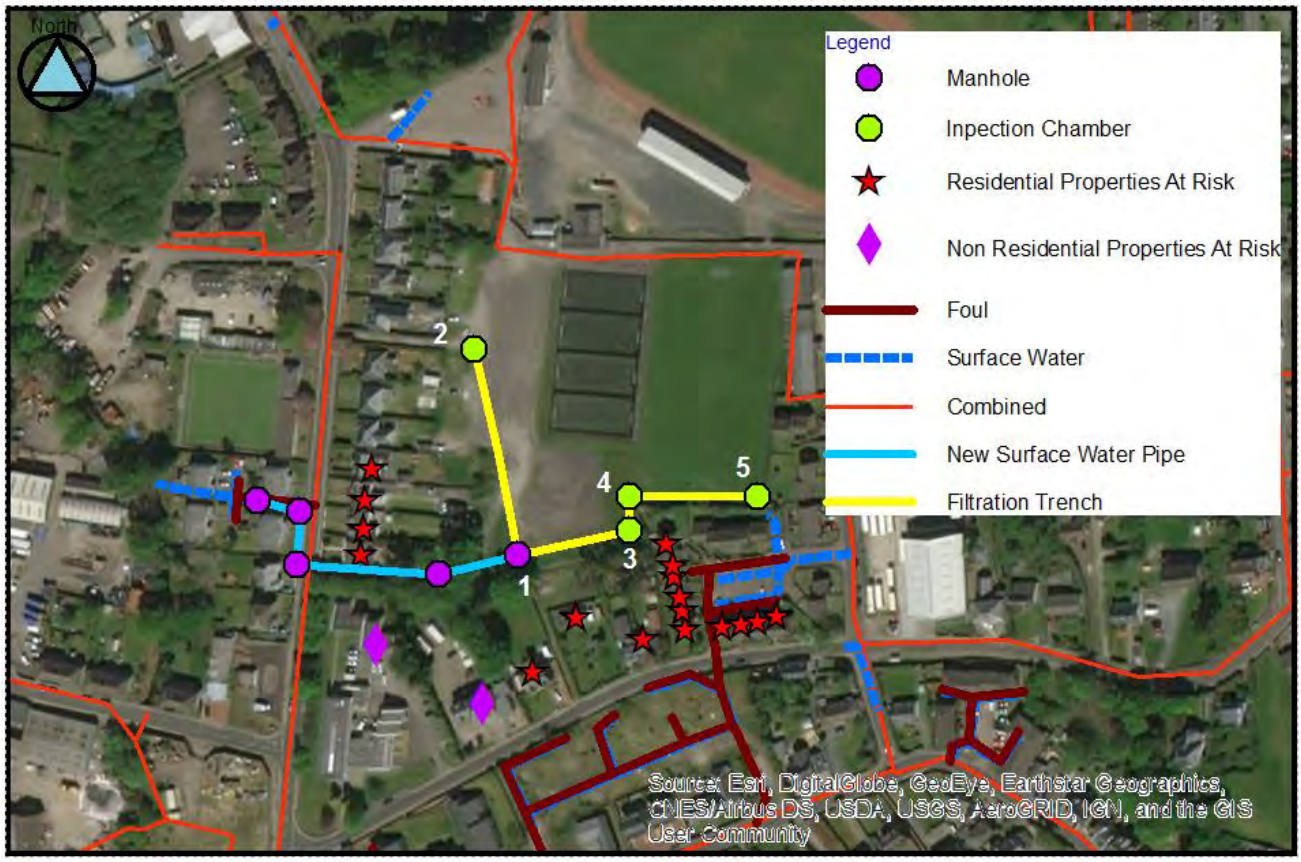
Pipe run	U/S Invert Level	D/S Invert Level	Length (m)	Gradient	Pipe size **(θ mm)**	Capacity (m3/s)
2-1	16.67	14.87	92	1:50	375	0.28
1-3	15.37	14.87	50	1:100	375	0.2
3-4	15.55	15.37	18	1:100	375	0.2
4-5	16.11	15.55	56	1:100	375	0.2

4.1.1 Option 1a: Filter trenches discharging to the Milton Burn

Ideally, it is preferred to remove surface water from the combined sewer particularly given the capacity issues in the Dunoon sewer network as advised by Scottish Water during the SWMP process. The route below passes through the rear ground of Dunoon Police Station before turning north up Argyll Road and onto a small housing development on Bogleha' Green. The information available from Scottish Water suggests that the separated network in this scheme discharges into a watercourse to the west. The surface water pipe in Bogleha' Green starts as a 150mm diameter pipe before increase to a 625mm pipe at a manhole in the centre of the development. The Scottish Water data available shows that the upstream extent of the 150mm diameter pipe is an adopted pipe with an invert level of 13.75mAOD.

The pipe run from Manhole No.1 is approximately 150m which results in a gradient of approximately 1:134. To convey the 1 in 200year+CC flow a 525mm diameter concrete pipe is required. It is proposed to connect to the upstream extent of the existing surface water network, replacing the smaller pipe with the proposed diameter. This may increase flood risk to the properties in the development and would need to be investigated further potentially resulting in upsizing of the downstream 625mm diameter pipe.

Figure 4-3: Outfall to Milton Burn



This option will consist of the following actions:

Creating 2 new filtration trenches in Black Park which will intercept surface water runoff. This will require 126m of 375mm diameter perforated PVC-U pipe and 4 inspection pits.

Construction of a new manhole chamber approximately 2m deep to collect flows from the filtration trenches (Manhole 1).

Construct approximately 150m of 525mm diameter concrete pipe with a further 3 manhole chambers. This will pass through the rear of Dunoon Police Station and will cross the combined sewer in Argyll Street of which the invert level is unknown.

Connect into the existing surface water drainage network of Bogleha' Green, upgrading the initial 10m (approximate) of 150mm diameter pipe with 625mm diameter pipe. This will then connect to the existing 625mm diameter pipe which discharges into the Milton Burn.

Decommission the existing pumping station and infill the existing channels using material excavated during construction of the filtration trenches.

Benefits of proposed scheme

This will offer a level of protection of up to 1:200 year + CC event for all properties known and predicted to be affected by flooding in Argyll Road, Argyll Street and Miller Court.

Sustainable approach as surface water is removed from the sewer network which will help to lower flood risk downstream in the network. This will also remove a substantial volume of surface water which would have been stored and treated.

No Land take in the park or on the pipe route (assuming Police Station land is available).

Conventional construction methods.

Low maintenance compared to existing pumping configuration and alternative open channel options.

The filtration trenches will allow for some infiltration in to ground water although this is not their primary function.

The filtration trenches will also allow for a degree of surface water storage.

Assumptions and risk

That the land in Black Park is owned by the council.

That access will be permitted to the grass strip at the rear of the police station.

That the drainage network within Bogleha' is adopted and the invert levels provided are correct.

That the proposed surface water pipe is able to pass over/under the combined sewer on Argyll Street and any other services found beneath the carriageway.

That the excavated material from the filter trenches are suitable as fill material in the existing drainage ditch.

That the drainage network in Bolgeha' Gardens could be retrofitted without increasing flood risk to residents.

That the outfall from Bogleha' Gardens is in good condition well above the invert of the channel and is fitted with a flap valve.

A alternative outfall could be sited in the council owned land bounding the Milton Burn immediately south of Bogleha' Gardens.

That these actions will not contribute to an increase in flood risk downstream from the Milton Burn

Costs

Item	Quantity	Units	Unit cost	cost	Source
General					
Site welfare	8	weeks	425	3400.00	CESMM3 Unit Costs
Site store	8	weeks	105.06	840.48	CESMM3 Unit Costs
Site supervision	6	weeks	1422	8532.00	CESMM3 Unit Costs
Traffic Management	6	weeks	1500	9000.00	Estimate
Filtration Trenches					
Excavation	128	m3	4.90	627.20	CESMM3 Unit Costs
Supply 375mm diameter perforated pipe	126	m	126.03	15879.78	WAVIN
Install pipe upto 2m deep	126	m	35.07	4418.82	CESMM3 Unit Costs
Precast Concrete Inspection chambers less than 2m deep	4	No.	1532.1	6128.40	CESMM3 Unit Costs
Backfill with Type B filter material	128	m3	50.51	6465.28	Highway Unit Costs
Move and place excavated material into old channel	128	m3	5.63	720.64	Highway Unit Costs
Surface Water Pipe to Bogleha' Garden					
Precast Concrete Manhole chambers less than 2m deep	4	No.	1532.1	6128.40	CESMM3 Unit Costs
Supply 525mm diameter concrete pipe	150	m	47.00	7050.00	Marshalls CPM Buyers Guide 2019
Install 525mm diameter concrete surface water pipe upto 2m deep	150	m	61.80	9270.00	CESMM3 Unit Costs
Supply 625mm diameter concrete pipe	10	m	£102	1016.10	Marshalls CPM Buyers Guide 2019
Replace 10m of 150mm dia with 625mm diameter	10	m	68.09	680.90	CESMM3 Unit Costs
Road Resurfacing					
200mm sub base (Type 1)	12	m3	8.14	457.68	CESMM3 Unit Costs
HRA Binder Course 80mm	60	m2	8.23	1093.80	CESMM3 Unit Costs
HRA Surface Course 60mm	60	m2	6.27	976.20	CESMM3 Unit Costs
Subtotal				82685.68	
Construction inflation index adjustment (2016 to 2019)	10.1	%		91036.93	OFNS
Optimism Bias	60			145659.09	
Detailed design costs	19			27675.23	
Total				173,334	

4.1.2 Option 1b: Filtration trench discharging to the combined sewer

An alternative to discharging to the Milton Burn would be to connect directly to the combined sewer. This is the current arrangement on site. Throughout the SWMP process it has been highlighted by Scottish Water that there is a significant dry weather flow in the network due to a significant number of surface water features connecting directly to the sewer network.

The combined sewer in Argyll Street is a 375mm diameter pipe which originates on Bogleha Road approximately 220m north of the proposed connection point on Argyll Street. As there are limited connection points before the proposed surface water connection point there is likely to a reasonable capacity remaining in the pipe. For the purpose of this exercise the surface water pipe leading from the filtration trenches will be limited to a 300mm diameter pipe. This will effectively limit the discharge from the filter trenches to 100l/s which is approximately equal to the 1:2 year flow.

Figure 4-4: Outfall to combined sewer

This option will consist of the following actions:

As per Option 1 up to Manhole 1 and decommissioning of existing drainage and pumping station.

Construct approximately 93m of new 300mm diameter twinwall PVC-U pipe from Manhole 1 to the proposed connection point on Argyll Street including the construction of 2No. manholes.

The manhole connecting the surface water pipe to the combined sewer shall be fitted with a non-return valve to prevent the combined sewer surcharging into the filtration trenches.

Decommission the existing pumping station and infill the existing channels using material excavated during construction of the filtration trenches.

Benefits of proposed scheme

This will offer a level of protection of up to 1:2 year event for all properties known and predicted to be affected by flooding in the Argyll Road, Argyll Street and Miller Court.

No Land take in the park or on the pipe route (assuming Police Station land is available).

Conventional construction methods.

Low maintenance compared to existing pumping configuration and alternative open channel options.

The filtration trenches will allow for some infiltration in to ground water although this is not their primary function.

The filtration trenches will also allow for a degree of surface water storage if the system is surcharging.

Assumptions and risk

That the land in Black Park is owned by the council.

That access will be permitted to the grass strip at the rear of the police station.

That Scottish Water will accept a new connection into the combined sewer in Argyll Street.

That the excavated material from the filter trenches are suitable as fill material in the existing drainage ditch.

That by directing surface water flows into the combined sewer the flood risk will increase to those downstream of the connection point.

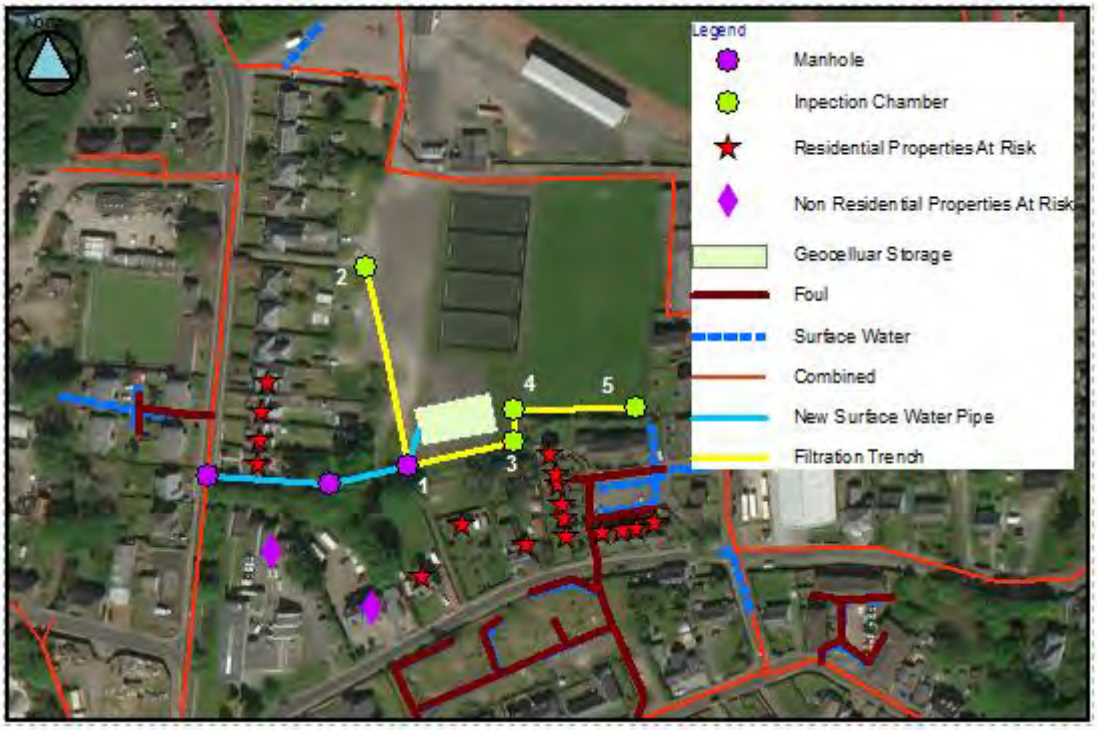
Costs

Item	Quantity	Units	Unit cost	cost	Source
General					
Site welfare	6	weeks	425	2550.00	CESMM3 Unit Costs
Site store	6	weeks	105.06	630.36	CESMM3 Unit Costs
Site supervision	6	weeks	1422	8532.00	CESMM3 Unit Costs
Traffic Management	3	weeks	1500	4500.00	Estimate
Filtration Trenches					
Excavation	128	m3	4.9	627.20	CESMM3 Unit Costs
Supply 375mm diameter perforated pipe	126	m	126.03	15879.78	WAVIN
Install pipe up to 2m deep	126	m	35.07	4418.82	CESMM3 Unit Costs
Precast Concrete Manhole chambers less than 2m deep	4	No.	1532.1	6128.40	CESMM3 Unit Costs
Backfill with Type B filter material	128	m3	50.51	6465.28	Highway Unit Costs
Move and place excavated material into old channel	128	m3	5.63	720.64	Highway Unit Costs
Surface Water Pipe to Argyll Street Combined Sewer					
Precast Concrete Manhole chambers less than 2m deep	3	No.	1532.1	4596.30	CESMM3 Unit Costs
Supply 525mm diameter concrete pipe	93	m	47	4371.00	Marshalls CPM Buyers Guide 2019
Install 525mm diameter concrete surface water pipe upto 2m deep	93	m	61.8	5747.40	CESMM3 Unit Costs
Road Resurfacing					
200mm subbase (Type 1)	2	m3	38.14	76.28	CESMM3 Unit Costs
HRA Binder Course 80mm	10	m2	8.23	182.30	CESMM3 Unit Costs
HRA Surface Course 60mm	10	m2	6.27	162.70	CESMM3 Unit Costs
Subtotal				65588.46	
Constuction inflation index adjustment (2016 to 2019)	10.1	%		72212.89	
Optimism Bias	60	%		115540.63	OFNS
Detailed design costs	19	%		21952.72	
Total				137,493	

4.2 Option 2 – Filtration trench connecting to the combined sewer (Option 1b) with underground storage.

This option is an addition to Option 1b that has the potential to increase the level of protection available however, it does not prevent surface water entering the combined sewer. For this option a flow control would be installed in Manhole No.1 to restrict flows to the 1:2year event which is the estimated capacity of the combined sewer on Argyll Street. When the flow control is activated flows will be diverted into a geocellular storage tank measuring approx. 25m x 45m x 1m which will contain 880m^3 of surface water. This will store water until the storm event has passed and there is sufficient capacity in the downstream network.

Figure 4-5: Outfall to combined sewer with geocellular storage



This option will consist of the following actions:

All actions listed in Option 1b.

Install a flow control in manhole No.1 to limit the pass forward flow to the 1:2 year flow.

Construct geocellular underground storage upstream of manhole No.1 measuring approximately 25m x 45m x 1m which provides 1125m^3 of storage. The invert level of the storage will be approximately 15.1mAOD and consist of 2No. Levels of geocellular storage with a minimum 0.7m of cover. This level of cover will allow the area to continue to be loaded with vehicular traffic.

Benefits of proposed scheme

As per Option 1b with the increased level of protection of up to the 1:50year event.

By controlling the flow this will help to prevent flooding downstream in the sewer network (compared to Option 1b) as flows can be held until the storm has passed and the sewer network has recovered.

Assumptions and risk

As per Option 1b.

The geocelluar storage will regular maintenance (jetting) to keep it fully functional.

Costs

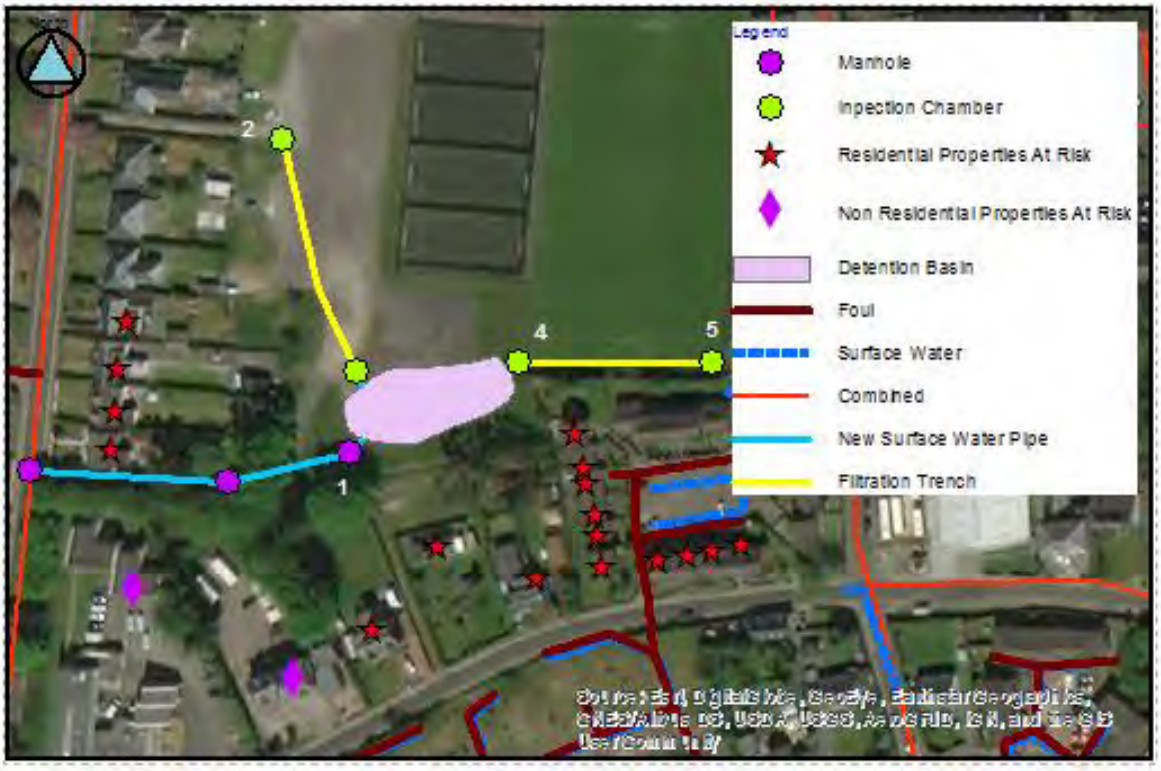
Item	Quantity	Units	Unit cost	cost	Source
General					
Site welfare	12	weeks	425	5100.00	CESMM3 Unit Costs
Site store	12	weeks	105.06	1260.72	CESMM3 Unit Costs
Site supervision	8	weeks	1422	11376.00	CESMM3 Unit Costs
Traffic Management	3	weeks	1500	4500.00	Estimate
Filtration Trenches					
Excavation	128	m3	4.9	627.20	CESMM3 Unit Costs
Supply 375mm dia perforated pipe	126	m	126.03	15879.78	WAVIN
Install pipe upto 2m deep	126	m	35.07	4418.82	CESMM3 Unit Costs
Precast Concrete Manhole chambers less than 2m deep	4	No.	1532.1	6128.40	CESMM3 Unit Costs
Backfill with Type B filter material	128	m3	50.51	6465.28	Highway Unit Costs
Move and place excavated material into old channel	128	m3	5.63	720.64	Highway Unit Costs
Surface Water Pipe to Argyll Street Combined Sewer					
Precast Concrete Manhole chambers less than 2m deep	3	No.	1532.1	4596.30	CESMM3 Unit Costs
Supply 525mm diameter concrete pipe	93	m	£47	4371.00	Marshalls CPM Buyers Guide 2019
Install 525mm diameter concrete surface water pipe upto 2m deep	93	m	61.8	5747.40	CESMM3 Unit Costs
Road Resurfacing					
200mm sub base (Type 1)	2	m3	38.14	76.28	CESMM3 Unit Costs
HRA Binder Course 80mm	10	m2	18.23	182.30	CESMM3 Unit Costs
HRA Surface Course 60mm	10	m2	6.27	162.70	CESMM3 Unit Costs
Install Geocellular Storage					
Excavation	1125	m3	4.9	5512.50	CESMM3 Unit Costs
Supply geocelluar storage	112.5	m3	100	112,500.00	Experience
install storage (drainage gang time only)	40	hr	9.45	3578.00	CESMM3 Unit Costs
Backfill and compact	125	3	.63	6333.75	

Item	Quantity	Units	Unit cost	cost	Source
Install flow control in Manhole No.1		No.	800	1800.00	Estimate
install 375mm diameter concrete pipe to storage		m	4.07	320.35	WAVIN
Subtotal				201657.42	
Construction inflation index adjustment (2016 to 2019)	10.1	%	-	222024.82	
Optimism Bias	60	%	-	355239.71	OFNS
Detailed design costs	19	%	-	67495.55	
Total				422,735	

4.3 Option 3 – Filtration trench connecting to the combined sewer (Option 1b) with above ground storage.

For this option the filtration trenches would be shortened and discharge directly into the detention basin via precast concrete headwalls. The detention basin has a storage volume of 2430m^3 and will discharge into manhole No1. which will have a flow control limiting the pass forward flow to 1:2 year event. This option will provide a level of protection of up to the 1:200 year+CC event.

Figure 4-6: Outfall to combined sewer with detention basin storage



This option will consist of the following actions:

All actions listed in Option 1b.

Install a flow control in Manhole No.1 to limit the pass forward flow to the 1:2 year flow.

Construct detention basin upstream of Manhole No.1 measuring approximately 45m x 25m x 1.8m (extending to a width of 35m at the top based on 1:3 slopes) which provides 2430m^3 of storage. The basin will be lined with a geosynthetic clay liner (GCL) to prevent seepage. The invert level of the storage will be approximately 15.1 mAOD and will have 2 inlets (filtration trenches) and single outlet (to manhole No.1).

Benefits of proposed scheme

As per Option 1b with the increased level of protection of up to the 1:200year+CC event.

By controlling the flow this will help to prevent flooding downstream in the sewer network (compared to Option 1b).

This will provide increased amenity benefit and improve biodiversity in the park.

Assumptions and risk

As per Option 1b.

The detention basin will require ongoing maintenance to ensure it remains operational.

That the excavated material from the filtration trenches is suitable for use as a fill material in the old drainage channel and maybe used for landscaping purposes within the park.

That the excavated material from the basin is non-hazardous and can be transported to a tip within 5km of the site or landscaped on site.

This option will require significant land stake from the car park area.

That the ground is of a permeable nature and the detention basin requires lining.

Costs

Item	Quantity	Units	Unit cost	cost	Source
General					
Site welfare	12	weeks	425	5100.00	CESMM3 Unit Costs
Site store	12	weeks	105.06	1260.72	CESMM3 Unit Costs
Site supervision	8	weeks	1422	11376.00	CESMM3 Unit Costs
Traffic Management	3	weeks	1500	4500.00	Estimate
Filtration Trenches					
Excavation	128	m3	4.9	627.20	CESMM3 Unit Costs
Supply 375mm diameter perforated pipe	126	m	126.03	15879.78	WAVIN
Install pipe up to 2m deep	126	m	35.07	4418.82	CESMM3 Unit Costs
Precast Concrete Manhole chambers less than 2m deep	4	No.	1532.1	6128.40	CESMM3 Unit Costs
Backfill with Type B filter material	128	m3	50.51	6465.28	Highway Unit Costs
Move and place excavated material into old channel	128	m3	5.63	720.64	Highway Unit Costs
Surface Water Pipe to Argyll Street Combined Sewer					
Precast Concrete Manhole chambers less than 2m deep	3	No.	1532.1	4596.30	CESMM3 Unit Costs
Supply 525mm diameter concrete pipe	93	m	47.00	4371.00	Marshalls CPM Buyers Guide 2019
Install 525mm diameter concrete surface water pipe upto 2m deep	93	m	61.8	5747.40	CESMM3 Unit Costs
Road Resurfacing					
200mm sub base (Type 1)	2	m3	38.14	76.28	CESMM3 Unit Costs
HRA Binder Course 80mm	10	m2	18.23	182.30	CESMM3 Unit Costs
HRA Surface Course 60mm	10	m2	6.27	162.70	CESMM3 Unit Costs
Construct Detention Basin					
Detention Basin					
Excavation	2430	m3	4.9	11907.00	CESMM3 Unit Costs
Install GCL Lining	1350	m2	5.43	7330.50	Naue + Highway Costs
Precast Concrete Headwall	3	No.	2500	7500.00	Estimate
Hydroseeding	350	m2	1.92	2592.00	CESMM3 Unit Costs
Move excavated (non-hazardous) material to tip not more than 5km for site includes tipping charges + tax	430	m3	8.59	118073.70	Highway Unit Costs

Item	Quantity	Units	Unit cost	cost	Source
Subtotal				219016.02	
Constuction inflation index adjustment (2016 to 2019)	10.1	%	-	241136.64	
Optimism Bias	60	%	-	385818.62	OFNS
Detailed design costs	19	%	-	73305.54	
Total				459,124	

5 Damages and benefits assessment

5.1 Guidance

In accordance with the Scottish Government's Appraisal Guidance, benefits are taken as Annual Average Damages (AAD) avoided by scheme options expressed as their Present Value (PV) using Treasury discount rates.

5.2 Damage methodology

Flood losses for this site can be broken down into two key aspects: direct flood damage to the 17 residential and 2 non-residential properties at risk; and indirect road damage repairs and clean up costs. Wider health and wellbeing aspects may also be applicable, along with road disruption and delay, but these are not considered to be significant at this stage.

Flood damages to properties are usually assessed for individual events and properties, or using higher level 'weighted annual average damage' datasets. SEPA's SPAADE dataset is recommended for SWMP studies and has been used here. The standard value of £1,100 (2010 values) has been updated to 2019 values using the Government GDP deflator series (2019 estimate of £1,284).

In order to determine the benefits of the scheme for a range of different standards of protection, the SPAADE value has been scaled using a weighting derived from FHRC's Weighed Annual Average Damage (WAAD) dataset.

The SPAADE values have been applied to each property and total present values over the appraisal period have been estimated by discounting future flood losses over a 100 year period.

5.3 Business case

In order to assess the economic viability of each option an analysis of the estimated construction costs versus the present value damages has been undertaken. The benefit-cost ratio is the total present value benefits divided by the total present value costs. A value above unity suggests that the scheme is economically viable. Further details on the cost analysis undertaken can be found in appendix A.

Table 5-1: Benefit-cost analysis of options

	Do Nothing	Option 1a	Option 1b	Option 2	Option 3
Level of protection offered	0	1:200yr+CC	1:2yr	1:50yr	1:200yr+CC
Estimated construction cost	0	£173,333	£137,493	£422,734	£459,124
Annual average damages	£21,834	£176	£21,834	£1,393	£176
Present Value damages	£2,826,511	£26,862	£2,826,511	£214,490	£26,862
Total PV damage	£2,945,763	£26,862	£2,826,511	£214,490	£26,862
Total PV benefits	-	£2,745,568	£119,252	£2,731,273	£2,918,901

	Do Nothing	Option 1a	Option 1b	Option 2	Option 3
Cost benefit ratio	-	16.8	0.9	6.5	6.4

All options bar option 1b have a benefit cost ratio greater than 1, thus the 3 remaining options are considered to be cost effective. Option 1a has the highest benefit-cost ratio and would be considered to be preferred option economically.

6 Choosing the Preferred Option

6.1 Method of assessing and prioritising options

The assessment process aims to scope measures that will achieve multiple objectives in the context of site constraints and future development. A Multi-Criteria Assessment (MCA) screening exercise has been completed to consider the relative merits of each measure. It is recognised that it is important to ensure options are compared thoroughly, consistently and carefully reviewing options against the following criteria:

Technical Feasibility – is it easily implemented?

Relative Cost – how expensive is it in comparison to other measures?

Economic Viability – is it expensive to implement?

Social Impact and Acceptability – how will it impact on residents?

Environmental – how will it impact the environment?

Sustainability – is it a sustainable approach?

Detailed cost estimates have not been prepared as the funding and delivery mechanisms are not yet known. Each management option will be scored against each of the criteria set out above using relative indicator, in line with UK guidance:

U - not applicable or unacceptable outcome

-2 - severely negative outcome

-1 - moderately negative outcome

0 - neutral outcome

+1 - moderately positive outcome, or

+2 - strongly positive outcome

The measures with the lowest overall combined scores from the MCA will be screened out to produce a short list of preferred options. The short-listed mitigation measures provide the starting point for a more detailed economic assessment should the Partners wish to take any of the sites further and implement surface water management measures.

Mitigation Measures	Technical	Relative Cost	Economic	Social Impact	Environment	Sustainability	Overall	Shortlist?
Option 1a Discharge to Milton Burn	0	0	0	+2	+2	+2	6	Yes
Option 2 Discharge to Combined Sewer + Underground storage	+1	-2	-2	+1	0	-1	-3	No
Option 3 Discharge to Combined Sewer + Above ground storage	+1	-1	0	+1	+1	+1	3	maybe

6.2 Determining the preferred option

The results of the MCA analysis above has shown that Option 1a is most favourable however, Option 3 should also be considered further.

The viability of Option 1a depends greatly on the location of the existing utilities in Argyll Street and whether or not the proposed surface water pipe can navigate these. Option 1a also requires retro fitting and upsizing pipes in the Bogleha' Green development which would need to be undertaken without increasing flood risk to the residents. This route was seen as the most viable route to connect with the Milton Burn. It may also be possible to connect to the burn further south by routing south on Argyll Street then west on to Hamilton Street. This route is substantially longer and requires more services to be crossed and a new headwall to be constructed. If the Bogleha' Green route proves unviable the route via Hamilton Street should be revisited ahead of option 3. This will remove significant volumes of surface water from the combined sewer network provided a sustainable solution.

Option 3 uses a detention basin to store and discharge surface water into the combined sewer in a controlled manner in order to prevent downstream flooding of the combined sewer. The above ground storage will result in a reduction in car parking spaces/event space at the park but could increase the amenity benefit significantly, increase biodiversity and access to greenspace. The cost-benefit ratio could be improved substantially if the excavated material was reused onsite.

7 Further studies

In order to progress to the preferred options, it would be prudent to undertake additional investigations to ensure the feasibility of the proposed options before the detailed design stage.

Topographic survey of the southern area of Black Park and the proposed discharge route/location.

Confirm service location and depths in Argyll Street, Bogleha' Green and Hamilton Street using a ground penetrating radar (GPR) survey and/or inspection pits.

Create a hydraulic model of the proposed design using software such as micro drainage to confirm levels, flows and pipe geometry.

Undertake a small ground investigation to inform reuse of insitu material and pipe material suitability.

If any option other than Option 1a is selected the capacity of the combined sewer will need to determined.

8 Conclusion

The analysis undertaken in this options appraisal study on flood risk mitigation measures at Black Park, Dunoon, has provided a preferred option based on the information available. The preferred option is Option 1a which involves:

Creating 2 new filtration trenches in Black Park which will intercept surface water runoff. This will require 126m of filtration trenches consisting of 375mm diameter perforated PVC-U pipe, SHW Type B filter material and 4 precast concrete inspection pits.

Construction of new precast concrete manhole chamber approximately 2m deep to collect flows from the filtration trenches.

Construction of approximately 150m of 525mm diameter concrete surface water pipe with a further 3 precast concrete manhole chambers. This will pass through the rear of Dunoon Police Station and will need to cross the combined sewer in Argyll Street of which the invert level is unknown.

Connecting into the existing surface water drainage network of Bogleha' Green, upgrading the initial 10m (approximate) with 625mm diameter pipe. This will then connect to the existing 625mm diameter pipe which discharges into the Milton Burn.

Decommission the existing pumping station and infill the existing channels using material excavated during construction of the filtration trenches.

This option has an estimated construction cost of approximately £173,334 includes an optimism bias of 60% which is standard practice at this level of design. The option explained above and indeed all of the options require further information and design in order to analyse detailed costs and risks.

Appendix

A Cost-Benefit Analysis

Project Summary Sheet

Client/Authority				Prepared (date)	02/07/2019
Argyll and Bute Council				Printed	25/10/2019
Project name				Prepared by	ST
Dunoon options appraisal - Black Park				Checked by	AEP
Project reference	2018s0549			Checked date	03/07/2019
Base date for estimates (year 0)	Jun-2019				
Scaling factor (e.g. £m, £k, £)	£	(used for all costs, losses and benefits)			
Year	0	30	75		
Discount Rate	3.5%	3.00%	2.50%		
Optimism bias adjustment factor	60%				

Costs and benefits of options

	Costs and benefits £				
Option name	Do-nothing	Option 1a	Option 1b	Option 2	Option 3
AEP or SoP (where relevant)	50%	0.5%	50%	2%	0.5%
COSTS:					
PV capital costs	0	108,333	85,933	264,209	286,953
PV operation and maintenance costs	0	0	0	0	0
PV other	0	0	0	0	0
Optimism bias adjustment	0	65,000	51,560	158,525	172,172
PV negative costs (e.g. sales)	0	0	0	0	0
PV contributions					
Total PV Costs £ excluding contributions	0	173,333	137,493	422,734	459,124
BENEFITS:					
PV monetised flood damages	2,826,511	26,862	2,826,511	214,490	26,862
PV monetised flood damages avoided		2,799,649	0	2,612,021	2,799,649
PV road drainage and clearing	119,252	0	0	0	0
PV road drainage and clearing avoided		119,252	119,252	119,252	119,252
Total monetised PV damages £	2,945,763	26,862	2,826,511	214,490	26,862
Total monetised PV benefits £		2,918,901	119,252	2,731,273	2,918,901
PV damages (from scoring and weighting)					
PV damages avoided/benefits (from scoring and weighting)					
PV benefits from ecosystem services					
Total PV damages £	2,945,763	26,862	2,826,511	214,490	26,862
Total PV benefits £		2,918,901	119,252	2,731,273	2,918,901
DECISION-MAKING CRITERIA:					
Based on monetised PV benefits (excludes benefits from scoring and weighting and ecosystem services)					
Net Present Value **NPV**		2,745,568	-18,241	2,308,539	2,459,777
Average benefit/cost ratio **BCR**		16.8	0.9	6.5	6.4
		Highest bcr			

Brief description of options:

Option 1	Do-nothing				
Option 2	Option 1a				
Option 3	Option 1b				
Option 4	Option 2				
Option 5	Option 3				

Comments and assumptions:

CLIENT	**Argyll and Bute Council**
PROJECT	**Dunoon options appraisal - Black Park**
SUMMARY	

Mandatory input by user
Optional input by user
Calculated by spreadsheet

PART 1: PROJECT DESCRIPTION

Project name	Dunoon options appraisal - Black Park
Project reference	2018s0549
Project location	**Dunoon options appraisal - Black Park**

PART 2: GENERALITIES

Test discount rate	3.5%	3.0%	2.5%
Appraisal period (years)	100		
PV factor for appraisal period	29.813		

PART 3: CALCULATION OF BENEFITS

3.1 Define the benefit area

Residential properties at risk for 200 year event (nr)	17	
Average property value (£)	149,036	
Flood warning? (None/<8 hour/>8 hour)	None	0

3.2 Direct damage to residential properties

	Standard of protection (return period)	Properties at risk	Properties protected (default)	Properties protected (default)	AAD per property	Total AAD
		nr	%	nr	£	£
1	No protection	0	n/a	0	£ 1,284	£ -
0.5	50% (2-years)	17	n/a	0	£ 1,284	£ 21,834
0.2	20% (5-years)	0	5%	0.85	£ 780	£ -
0.1	10% (10-years)	0	10%	0.85	£ 402	£ -
0.04	4% (25-years)	0	25%	2.55	£ 192	£ -
0.02	2% (50-years)	0	80%	9.35	£ 82	£ -
0.01	1% (100-years)	0	93%	2.21	£ 20	£ -
0.005	0.5% (200-years)	0	100%	1.19	£ 10	£ -
	Total	**17**		**17**		**£ 21,834**
	PV damage (PVd)					**£ 650,944**
	Write-off value					£ 2,533,612
	PVd capped					**£ 650,944**

3.3 Direct damage to non-residential properties

Standard of protection (return period)	Retail	Offices	Warehouses	Leisure	Playing Field	Sports Centre	Marina	Sports Stadium	Public Buildings	Industry	Car park	SubStation	NRP sector average	Total AAD
	Properties protected													
	2	**3**	**4**	**51**	**521**	**523**	**526**	**525**	**6**	**8**	**910**	**960**		
	nr	nr	nr	nr	nr	nr	nr	nr	nr	nr	nr	nr	nr	£
No protection		1							1					£ 72,974
20% (5-years)														£ -
10% (10-years)														£ -
4% (25-years)														£ -
2% (50-years)														£ -
1% (100-years)														£ -
0.5% (200-years)														£ -
Total	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**£ 72,974**
PVd non-residential														**£ 2,175,567**

3.4 Other flood losses: road disruption and emergency costs

		Property Count	Percentage Properties	Percentage Damage	
Direct damage: residential		17	94.4%	23.0%	£ 650,944
Direct damage: non-residential		1	5.6%	77.0%	£ 2,175,567
Sub-total: direct damage	**Total**	**18**	**100%**	**100%**	**£ 2,826,511**
TOTAL PVd					**£ 2,826,511**

CLIENT	**Argyll and Bute Council**
PROJECT	**Dunoon options appraisal - Black Park**
SUMMARY	

Mandatory input by user
Optional input by user
Calculated by spreadsheet

PART 1: PROJECT DESCRIPTION

Project name	Dunoon options appraisal - Black Park
Project reference	2018s0549
Project location	**Dunoon options appraisal - Black Park**

PART 2: GENERALITIES

Test discount rate	3.5%	3.0%	2.5%
Appraisal period (years)	100		
PV factor for appraisal period	29.813		

PART 3: CALCULATION OF BENEFITS

3.1 Define the benefit area

Residential properties at risk for 200 year event (nr)	17	
Average property value (£)	149,036	
Flood warning? (None/<8 hour/>8 hour)	None	0

3.2 Direct damage to residential properties

	Standard of protection (return period)	Properties at risk	Properties protected (default)	Properties protected (default)	AAD per property	Total AAD
		nr	%	nr	£	£
1	No protection	0	n/a	0	£ 1,284	£ -
0.5	50% (2-years)	0	n/a	0	£ 1,284	£ -
0.2	20% (5-years)	0	5%	0.85	£ 780	£ -
0.1	10% (10-years)	0	10%	0.85	£ 402	£ -
0.04	4% (25-years)	0	25%	2.55	£ 192	£ -
0.02	2% (50-years)	17	80%	9.35	£ 82	£ 1,393
0.01	1% (100-years)	0	93%	2.21	£ 20	£ -
0.005	0.5% (200-years)	0	100%	1.19	£ 10	£ -
	Total	**17**		**17**		**£ 1,393**
	PV damage (PVd)					**£ 41,541**
	Write-off value					£ 2,533,612
	PVd capped					**£ 41,541**

3.3 Direct damage to non-residential properties

	Standard of protection (return period)	Properties protected: Retail	Offices	Warehouses	Leisure	Playing Field	Sports Centre	Marina	Sports Stadium	Public Buildings	Industry	Car park	SubStation	NRP sector average	Total AAD
		2	3	4	51	521	523	526	525	6	8	910	960		
		nr	nr	nr	nr	nr	nr	nr	nr	nr	nr	nr	nr	nr	£
	No protection														£ -
	20% (5-years)														£ -
	10% (10-years)														£ -
	4% (25-years)														£ -
	2% (50-years)		1							1					£ 5,801
	1% (100-years)														£ -
	0.5% (200-years)														£ -
	Total	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**£ 5,801**
	PVd non-residential														**£ 172,949**

3.4 Other flood losses: road disruption and emergency costs

		Property Count	Percentage Properties	Percentage Damage	
Direct damage: residential		17	94.4%	19.4%	£ 41,541
Direct damage: non-residential		1	5.6%	80.6%	£ 172,949
Sub-total: direct damage	**Total**	**18**	**100%**	**100%**	**£ 214,490**
TOTAL PVd					**£ 214,490**

CLIENT	**Argyll and Bute Council**
PROJECT	**Dunoon options appraisal - Black Park**
SUMMARY	

Mandatory input by user
Optional input by user
Calculated by spreadsheet

PART 1: PROJECT DESCRIPTION

Project name	Dunoon options appraisal - Black Park
Project reference	2018s0549
Project location	**Dunoon options appraisal - Black Park**

PART 2: GENERALITIES

Test discount rate	3.5%	3.0%	2.5%
Appraisal period (years)	100		
PV factor for appraisal period	29.813		

PART 3: CALCULATION OF BENEFITS

3.1 Define the benefit area

Residential properties at risk for 200 year event (nr)	17	
Average property value (£)	149,036	
Flood warning? (None/<8 hour/>8 hour)	None	0

3.2 Direct damage to residential properties

	Standard of protection (return period)	Properties at risk	Properties protected (default)	Properties protected (default)	AAD per property	Total AAD
		nr	%	nr	£	£
1	No protection	0	n/a	0	£ 1,284	£ -
0.5	50% (2-years)		n/a	0	£ 1,284	£ -
0.2	20% (5-years)	0	5%	0.85	£ 780	£ -
0.1	10% (10-years)	0	10%	0.85	£ 402	£ -
0.04	4% (25-years)	0	25%	2.55	£ 192	£ -
0.02	2% (50-years)	0	80%	9.35	£ 82	£ -
0.01	1% (100-years)	0	93%	2.21	£ 20	£ -
0.005	0.5% (200-years)	17	100%	1.19	£ 10	£ 176
	Total	**17**		**17**		**£ 176**
	PV damage (PVd)					**£ 5,243**
	Write-off value					£ 2,533,612
	PVd capped					**£ 5,243**

3.3 Direct damage to non-residential properties

	Standard of protection (return period)	Properties protected: Retail	Offices	Warehouses	Leisure	Playing Field	Sports Centre	Marina	Sports Stadium	Public Buildings	Industry	Car park	SubStation	NRP sector average	Total AAD
		2	3	4	51	521	523	526	525	6	8	910	960		
		nr	nr	nr	nr	nr	nr	nr	nr	nr	nr	nr	nr	nr	£
	No protection														£ -
	20% (5-years)														£ -
	10% (10-years)														£ -
	4% (25-years)														£ -
	2% (50-years)														£ -
	1% (100-years)														£ -
	0.5% (200-years)		1							1					£ 725
	Total	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**£ 725**
	PVd non-residential														**£ 21,619**

3.4 Other flood losses: road disruption and emergency costs

		Property Count	Percentage Properties	Percentage Damage	
Direct damage: residential		17	94.4%	19.5%	£ 5,243
Direct damage: non-residential		1	5.6%	80.5%	£ 21,619
Sub-total: direct damage	**Total**	**18**	**100%**	**100%**	**£ 26,862**
TOTAL PVd					**£ 26,862**

Offices at

Coleshill
Doncaster
Dublin
Edinburgh
Exeter
Glasgow
Haywards Heath
Isle of Man
Limerick
Newcastle upon Tyne
Newport
Peterborough
Saltaire
Skipton
Tadcaster
Thirsk
Wallingford
Warrington

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