West Indies Home Contractors Limited

WHIMS HOUSING DEVELOPMENT

Old Harbour, St. Catherine

Engineering Hydrology, Drainage Study and Flood Mapping

FEBRUARY 2009

An Assessment of Storm Water Peak Flows and Inundation Risks Related to the Bower's Gully

Prepared by

Fluid Systems Engineering Limited

Kingston, Jamaica

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1. Executive Summary

The WHIMS HOUSING DEVELOPMENT is being undertaken by West Indies Home Contractors Limited as part of it business initiative to bring low/middle income housing solutions to the Jamaican real estate market. The WHIMS, a follow-on project to the successful Aviary Housing Development, is situated to the south of the town of Old Harbour bounded by the toll highway to the north and the Old Harbour to Old Harbour Bay main road to the east.

The WHIMS a 104 hectare parcel of land, will see the construction of approximately 1,200 houses in various detached and row house configurations.

There are several significant drainage features within the vicinity of the project area which had to be evaluated to determine their likely impact on the proposed development. These include; The Bower's Gully to the west of the site, the WHIMS Gully which drains Old Harbour Town and the development site, the Old Harbour Bay Gully which is a continuation of the WHIMS Gully and a drainage channel to the east of Old Harbour Bay through the old fish ponds. The latter shares some of the WHIMS Gully flow with the Old Harbour Bay Gully.

Fluid Systems Engineering Limited was commissioned by WIHCON to undertake a hydrology and hydraulics study of the entire Bower's Gully and to produce inundation mapping for selected reaches of the gully, so as to determine the following;

Hydrology for Bowers Gully to Old Harbour Main Road
Hydrology and Drainage of Aviary, Rhodens Pen and Colbeck
Channel Hydraulics, Flood Mapping of Aviary, Rhodens Pen
Technical Note: Recommend area for development
Hydrology for Old Harbour Main Road to Gully Sea Discharge
Interim Report: Q and WL estimate req'd for WHIMS East Design
Hydrology and Drainage of WHIMS (East and West)
Channel Hydraulics, Flood Mapping of WHIMS
Final Report: Hydrology, Hydraulics, Flood Maps, Sectional Peak Flows

Findings and Recommendations

Hydrology for Bowers Gully to Old Harbour Main Road: This section of the study sought to ratify the original work done by Mr. Ruddy Harrison of Beckford and Dixon, Consulting Engineers some years earlier. The peak flows that were determined then, provided the basis for the design of the re-alignment of the section of Bower's Gully adjacent to the Aviary Housing Development.

The estimated runoff in Bower's Gully for the 1:100 year design event, at the Old Harbour Main Road Bridge is 358m^3/s. This flow coincides with the recommended design figure of 12,000 cfs determined by Beckford and Dixon.

Hydrology and Drainage of Aviary, Rhodens Pen and Colbeck: Our general understanding of the hydraulic regime that existed for many years is that the road crossing at Lennansville, acted in effect as a weir on the river limiting discharge to the downstream channel. All storm flow in excess of the limited capacity of the road bridge was diverted to over-bank flow to the west of the channel, into an expansive low lying agricultural area. This regulated discharge to the lower reach of the dry river from Lennansville to the Old Harbour Main Road and beyond.

When the road bridge was destroyed during hurricane Dennis, an un-restricted discharge of storm flow to the lower reach of the river occurred with the regulation normally provided by the road bridge removed.

Channel Hydraulics, Flood Mapping of Aviary, Rhodens Pen: The bridges at the Old Harbour Main Road and at the JRC railway will just accommodate the design storm under ideal channel conditions, i.e, no obstructions from trees, sediment or other debris in the channel or at the structures. This is however subject to having no significant backwater effects from the channel and hydraulic structures downstream of these crossings.

Technical Note - Recommend area for development: Rhoden's Pen is subject to a significant flood risk. Over 70% of the property is expected to be inundated for the 1:100 year design storm. A significant percentage of the area will be inundated by greater than 1m of water.

The maximum water level at the confluence for the 1:100 year design storm is 8.825m as indicated in the profile insert to Figure 14. This was confirmed as indicated in Figure 17, i.e., 8.19m being nominally below the above figure. This was expected as the detailed survey data provided for a much wider section of overbank flow than what was used in the initial basic hydraulic study.

There is only a 3% increase in peak flow i.e., 317 to 327m^3/s below the proposed confluence of the drain from the new development despite the discharge of 55m^3/s from the proposed development. This is entirely because of the early discharge into the gully from the efficiently drained lower sub-basins which include the proposed development.

The predicted water levels in the Lower Bower's Gully, clearly show flooding of the western sections of the communities of Burkesfield and Terminal. Anecdotal information confirmed that during all recent major rain storm events, flooding from the Bower's Gully was experienced in both communities with water depths in "Terminal" at some instances being over 0.5m at the peak stage.

Based on the findings of the hydraulic analysis of the lower reach of the Bower's Gully, it would seem that an inexpensive intervention could alleviate most of the river flooding experienced in the communities of Burkesfield and Terminal.

2. Introduction

The WHIMS HOUSING DEVELOPMENT is being undertaken by West Indies Home Contractors Limited as part of it business initiative to bring low/middle income housing solutions to the Jamaican real estate market. The WHIMS, a follow-on project to the successful Aviary Housing Development, is situated to the south of the town of Old Harbour bounded by the toll highway to the north and the Old Harbour to Old Harbour Bay main road to the east.

The WHIMS a 104 hectare parcel of land, will see the construction of approximately 1,200 houses in various detached and row house configurations. The development will also include spaces reserved for green areas, parks, schools and commercial development.

There are several significant drainage features within the vicinity of the project area which will need to be evaluated to determine their likely impact on the proposed development. These include; The Bower's Gully to the west of the site, the WHIMS Gully which drains Old Harbour Town and the development site, the Old Harbour Bay Gully which is a continuation of the WHIMS Gully and a drainage channel to the east of Old Harbour Bay through the old fish ponds to Dagger Bay. The latter shares some of the WHIMS Gully flow with the Old Harbour Bay Gully.

The town of Old Harbour Bay is low lying relative to sea level and has suffered historically from flooding related to hurricane storm surge and also from storm runoff associated with the various gullies that flow through and in the vicinity of the town.

Fluid Systems Engineering Limited was commissioned by WIHCON to undertake a hydrology and hydraulics study of the entire Bower's Gully and to produce inundation mapping for selected reaches of the gully, so as to determine the following;

3. Basis of Design

The basis of design with respect to capacities of structures and the overall performance of the drainage system, is typically stated as the design return period to which recommended capacities would not be exceeded. It is also expected that at these capacities, the structures and system would not suffer damage that would require rehabilitation at a cost that is significant in relation to the original investment.

We are to be guided primarily by the National design practice for Jamaica, that requires bridge and culvert capacity for primary drainage channels at all public road crossings, to convey T_{25} design flow with 25% depth of flow additionally as freeboard. The 25% addition is expected to provide T_{100} capacity without freeboard.

Guidelines set by the Jamaica Institution of Engineers, for the provision of drainage to housing subdivisions require the following;

i) Lots will discharge surface flows to the roads or directly to drainage channels. Secondary drainage channels and roads will accommodate storm flows of 1:5 years to freeboard level and a minimum of 1:2 years to the crown of the road respectively as is appropriate.

ii) Primary subdivision drainage channels will be designed to accommodate storms to 1:25 year return period with a freeboard provision of 25% depth of flow. Alternately, the channels will provide capacity for the 1:100 year design storm at top bank levels.

iii) Where required, flood peak discharge attenuation techniques will be employed to limit the discharge of urban runoff where downstream interests outside of the project site might be affected.

iv) The capacity of drainage channels and structures through which storm waters will be discharged from the development, must be checked to ensure that flows for a 1:100 year storm event from both the subdivision and other contributing areas can be conveyed adequately.

Along with the above, it is clear that where there are known plans for development that will impact the project area, these should be taken into consideration during the design process.

Drainage is assessed on the basis a statistically determine depth of rainfall applied to drainage basins and the extent to which this precipitation is converted to runoff is determined by hydrologic parameters set by land-use and soils data based on hydrologic soils classification.

Rainfall data over an extended period of at least 30 years is normally required for statistical classification. Where such data is not available for the design location, it is acceptable that data from a comparable geographic location can be used.

The above design criteria have been adopted for the project.

4. Site Location and Key Geographic Features

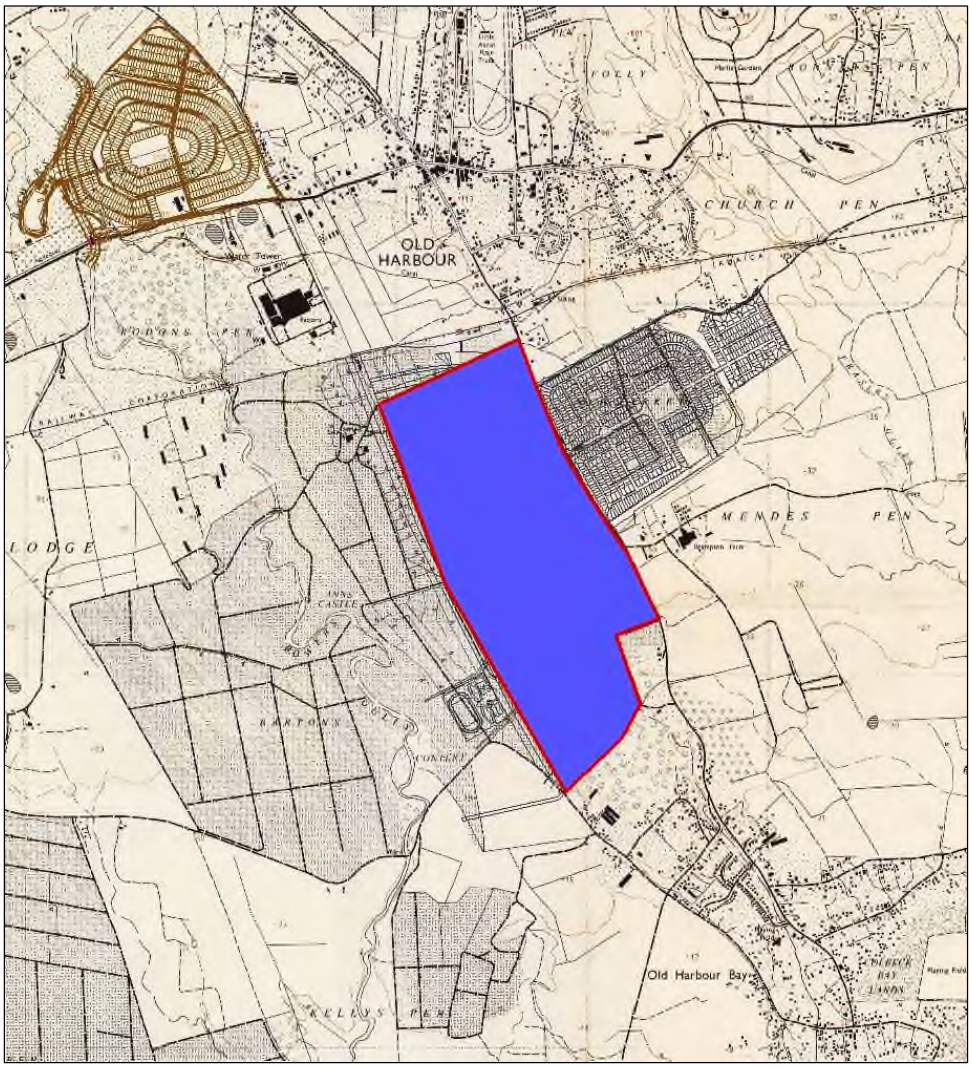

Figure 1: Location Plan, WHIMS Housing Development

The WHIMS, is situated to the south of the town of Old Harbour bounded by the toll highway to the north and the Old Harbour to Old Harbour Bay main road to the east.

There are several significant drainage features within the vicinity of the project area which will need to be evaluated to determine their likely impact on the proposed development. These include; The Bower's Gully to the west of the site, the WHIMS Gully which drains Old Harbour Town and the development site, the Old Harbour Bay Gully which is a continuation of the WHIMS Gully and a drainage channel to the east of Old Harbour Bay through the old fish ponds to Dagger Bay. The latter shares some of the WHIMS Gully flow with the Old Harbour Bay Gully.

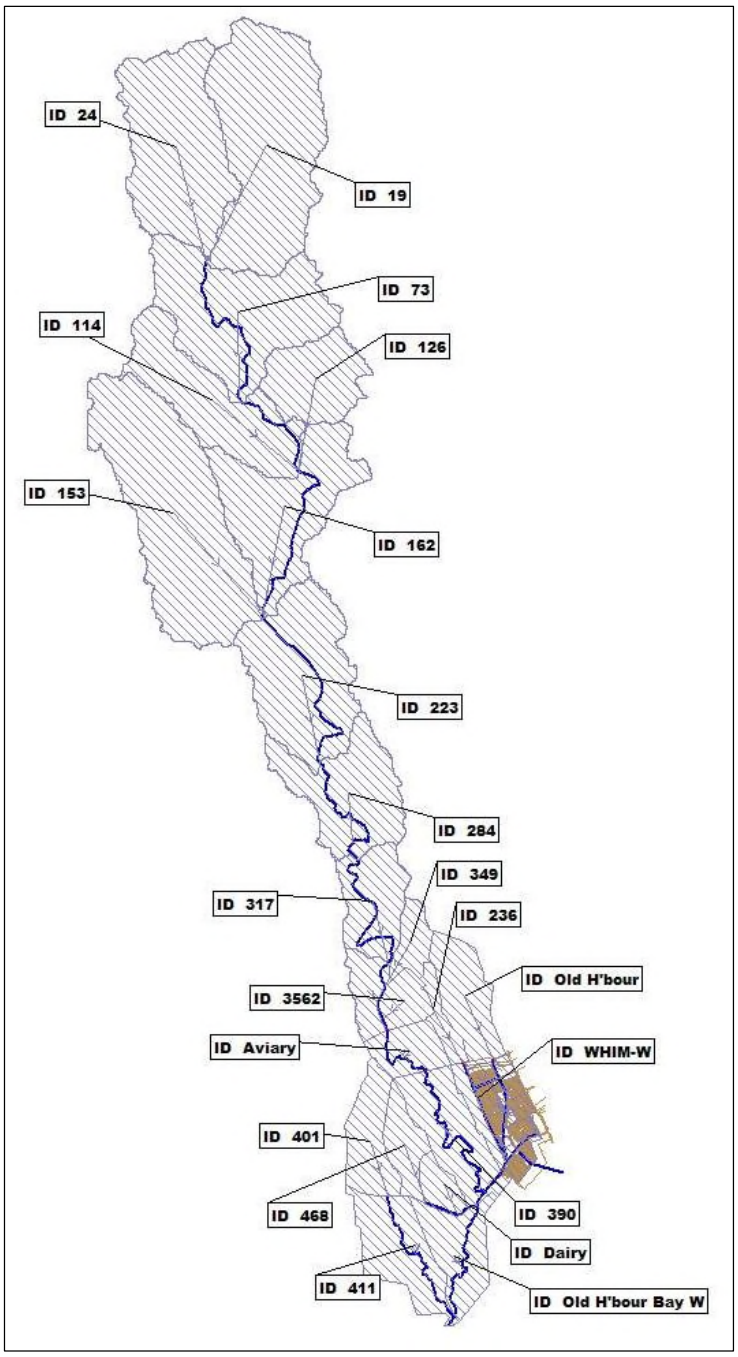

Figure 2: Bower's Gully and Catchment Area with main drainage sub-basins

The Bower's Gully and its catchment area, approximately 4074 hectare, is shown above with the delineation of the main drainage sub-basins. The 104 hectare WHIMS development is shaded in the lower right of the map.

The primary drains proposed for the WHIMS development will be diverted to the Bower's Gully except for a small southerly area. This is a major feature of the drainage strategy as it will relieve much of the flood risk to Old Harbour Bay related to storm water runoff.

5. Data Preparation for Hydrology Modeling

5.1. Delineation of the drainage basin

The Bower's Gully drainage sub-basins were delineated from published topographic mapping of the study area including a DTM prepared from InSAR observations, digitized and raster published topographic maps at 1:12,500 and 1:5000 and also from ground surveys.

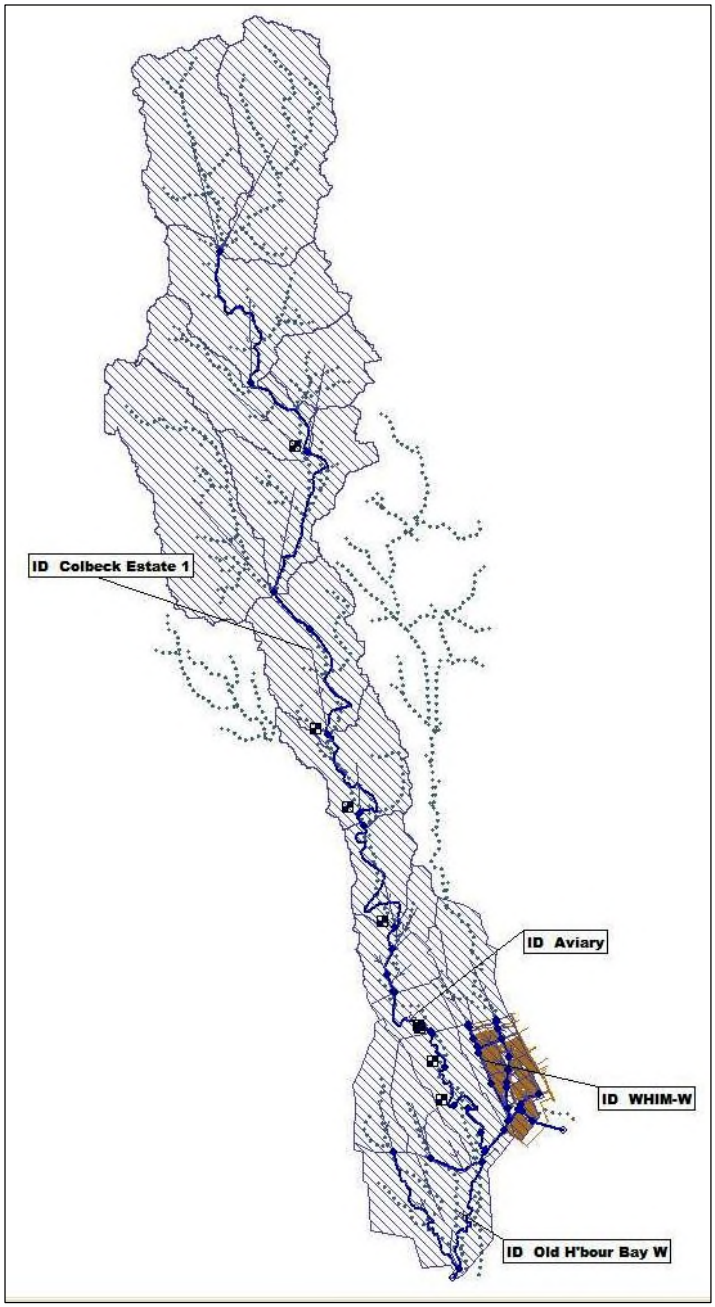

Figure 3: Bower's Gully, Delineation of catchment and 33 sub-basins

The existing topographic mapping was also used to verify drainage routes and to identify the location of the major drainage structures. Field inspections were carried out of all the major drainage structures and several local interviews were conducted as a final verification of drainage routes.

5.2. Definition of Hydrologic Soil Groups

Published soils data prepared by the Rural Physical Planning Unit of the Ministry of Agriculture was extracted to define the hydrologic soil groups (HSG) in the drainage basin.

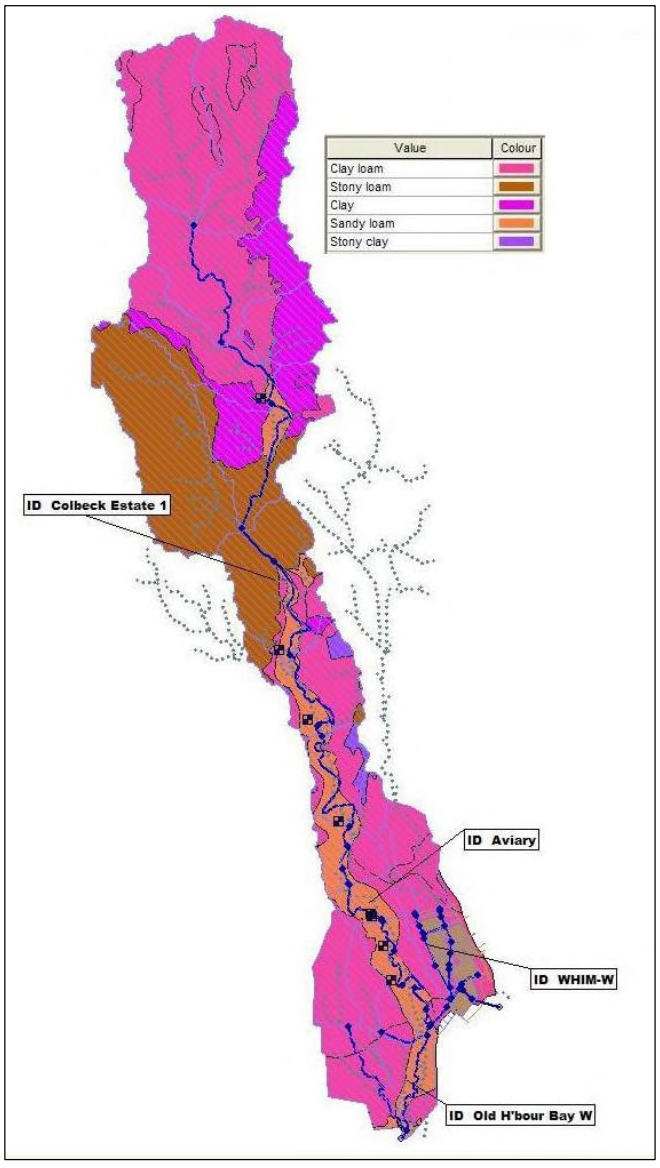

Figure 4: Hydrologic Soil Groups within study area with soil textures index

Soils are classified into four HSG's (A, B, C, and D) according to their minimum infiltration rate, which is obtained for bare soil after prolonged wetting consistent with the schedules published by the Natural Resources Conservation Services (NRCS) TR-55.

5.3. Definition of Land Use

5.3.1. WHIMS Project - Pre and Post development Land Use

Land use data for the analysis was taken from published maps, aerial photography and various sources of satellite imagery. The land use coverage of the study area was prepared firstly for the assessment of the current hydrologic condition. This "baseline" data is used to evaluate peak flow and storm volume estimates prior applying the proposed land use changes.

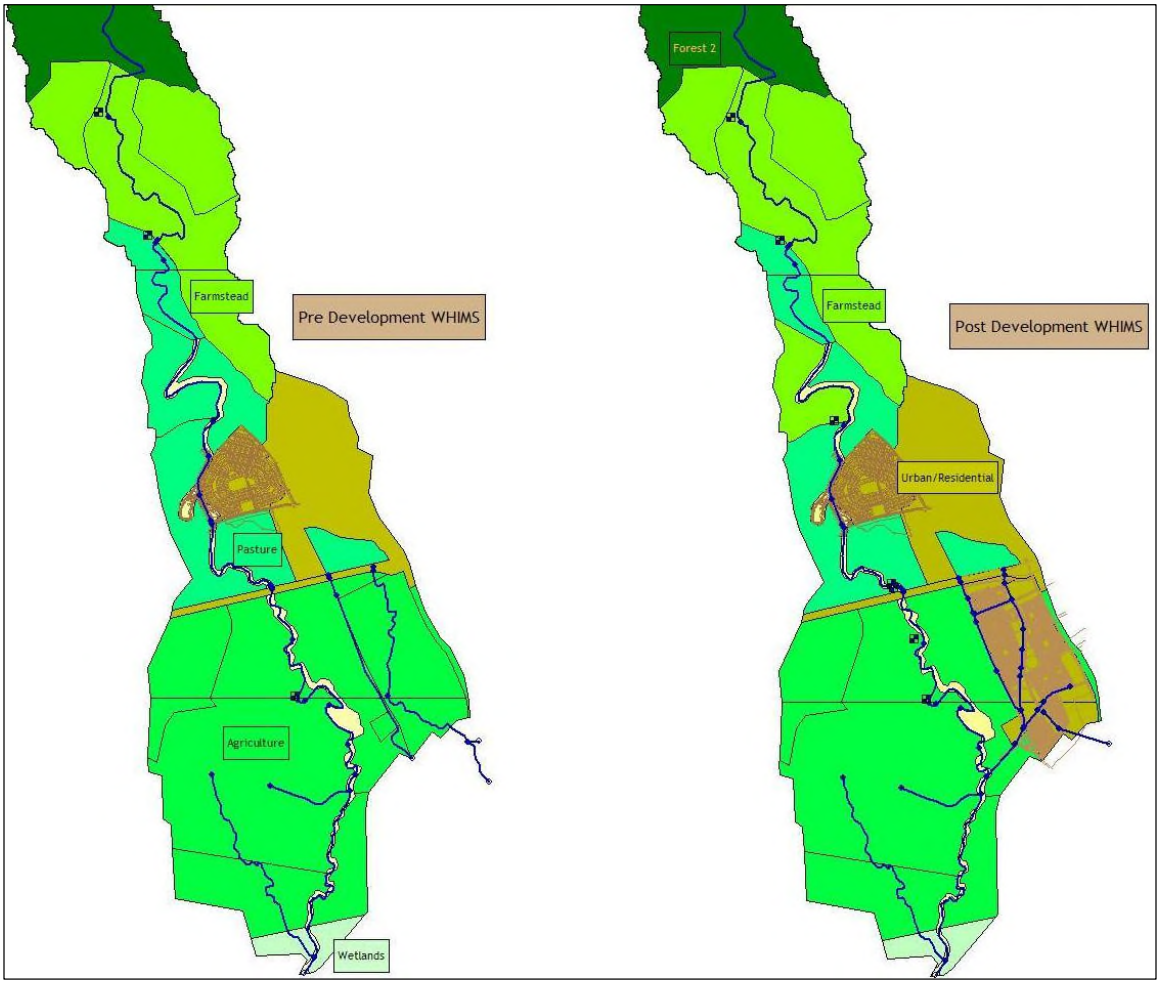

Figure 5: Pre and Post WHIMS, Land Use of populated areas in Bowers catchment

The land use changes that will be brought about by the proposed WHIMS development are assessment for the post-development hydrologic condition of the catchment area, facilitating a comparison of the estimated peak flows and storm volumes for the two scenarios. Figure 5 shows the pre and post development land uses.

Land use was classified into categories consistent with the schedules published by the Natural Resources Conservation Services (NRCS) TR-55 for cover type and hydrologic condition.

5.3.2. WHIMS Project - Pre and Post development drains

The existing and proposed i.e., "Pre - Post" drains, drainage areas and routes for the WHIMS development area are shown below in Figure 6. The areas hatched in red, show the sections of the catchment that currently drain through or impact Old Harbour Bay for the "Pre-WHIMS" scenario. For the "Post-WHIMS" scenario, the significantly reduced hatched area that will drain through or impact Old Harbour Bay is also shown.

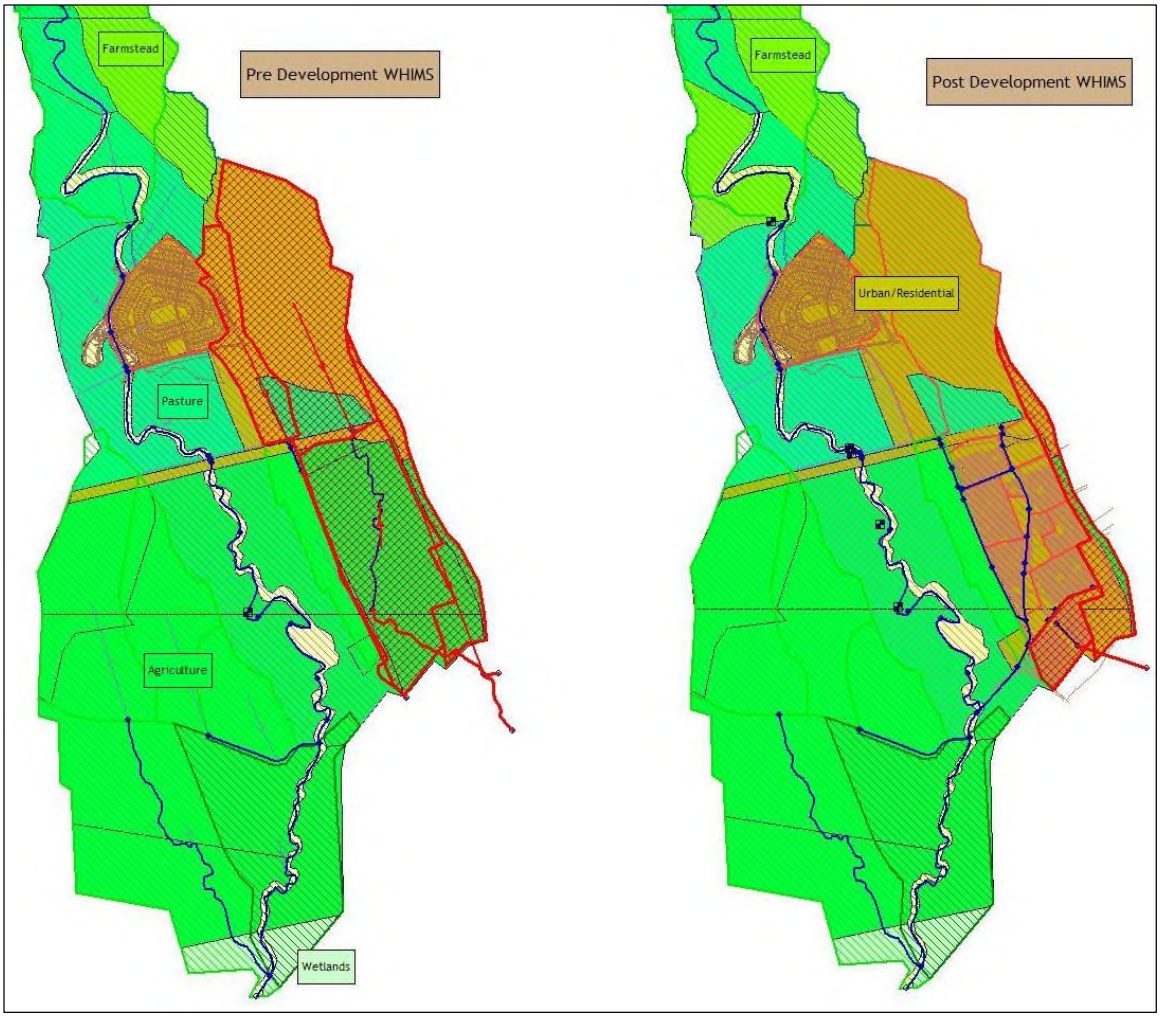

Figure 6: Pre and Post WHIMS, Drains and drainage routes

For the "Pre-WHIMS" or existing arrangement, an area of approximately 273 hectares, consisting of the Old Harbour urban centre the undeveloped WHIMS, drains through Old Harbour Bay via one of three routes. The eastern route along the Old Harbour Bay Main Road carries the majority of the storm water. It splits with some of the flow passing across the main road and heading to Dagger Bay while the main route continues just to the east of the primary school and then passes through the town west of the police station. The third route is a drain along a road to the west of the town. This drain eventually joins with the main drain through the town before it enters the sea.

The existing drainage arrangement for the town of Old Harbour Bay is totally inadequate. Recognizing this, under the WHIMS development project, it is proposed that the vast majority i.e., 228 hectares of the existing study drainage area will be diverted to the Bower's Gully away from the Old Harbour Bay Town. Approximately 45 hectares will continue to flow towards the town consisting of 29 hectares of undeveloped land (JPSCO reserve) and 16 hectares of the proposed new development.

For the "Post-WHIMS" land use shown in Figure 6, the "Farmstead" area shown west of Bower's Gully in the upper section of the diagram, is a section of the proposed development of "Colbeck" that will drain into the study catchment.

5.4. Rainfall Data for the Study Area

Rainfall data for Jamaica is published by the Meteorological Services Division for a network of rain gauges distributed throughout the island. For each station, based on the availability of sufficient data, return period statistical estimates of T_2 through T_{100} for 24 hour depth of precipitation is provided. The data from five gauging stations (as highlighted in the table below) was applied to the study area i.e., for the 1:25 year event, the 24 hour depth of rainfall for Old Harbour of 252mm is taken.

5.4.1. Published Rainfall Data – Bower's Gully Catchment Area

LOCATION	PARISH	YEARS_OF_R	T5	T10	T25	T50	T100
Above Rocks	St. Catherine	20	193	250	323	377	430
Amity Hall	St. Catherine	14	127	151	181	204	226
Bellas Gate	St. Catherine	33	197	251	320	371	421
Bernard Lodge	St. Catherine	22	183	234	298	345	392
Blair Pen	St. Catherine	12	132	170	219	255	291
Bodles	St. Catherine	23	140	170	208	236	264
Bog Walk	St. Catherine	25	152	187	231	264	296
Boists Cnt/Cocoa W	St. Catherine	16	189	236	296	340	384
Browns Hall	St. Catherine	30	214	273	349	405	461
Linstead	St. Catherine	41	184	231	290	334	378
Old Harbour	St. Catherine	48	164	203	252	288	324

Table 1: Published rainfall data from 24 hour records

5.4.2. Location of Rain Gauges – Bower's Gully Catchment Area

The elongated geometry of the Bower's Gully catchment area is influenced by several rainfall gauging stations as indicated in Figure 7 below. The spatial application of the depth of rainfall from the five stations to the catchment was done using Thiessen polygons which are also shown in the figure.

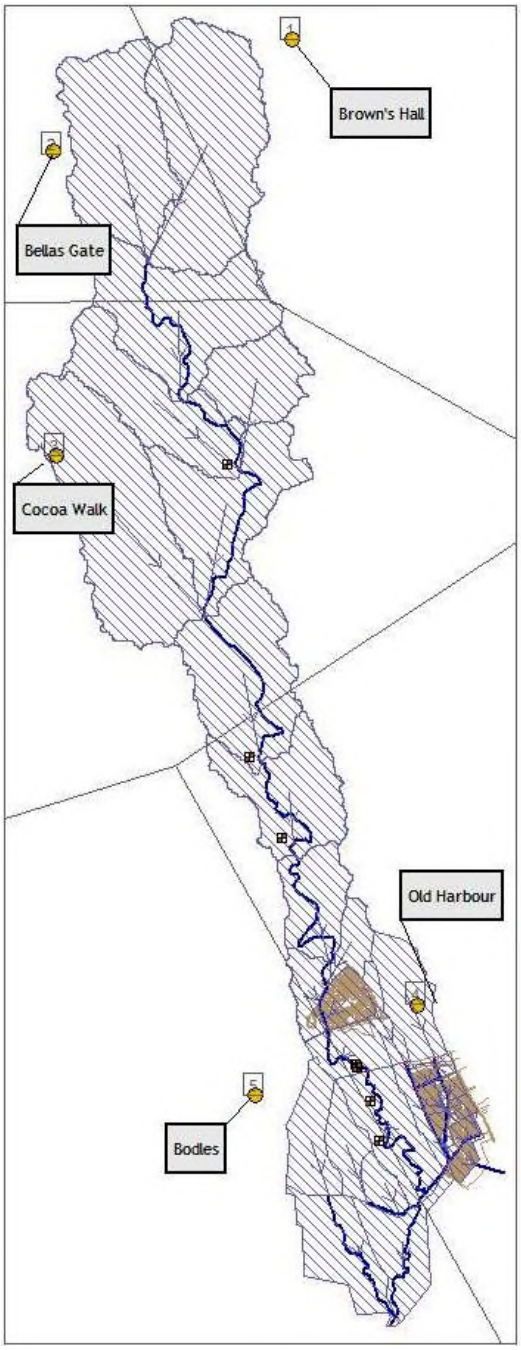

Figure 7: Location of gauging station s relative to Bower's Gully catchment

5.4.3. Design Storm Rainfall Distribution – WRA Jamaica

The rainfall distributions shown below in Figure 8 were developed by the Water Resources Authority have been used as design storm distributions in relation to the published 24 hour precipitation data.

For the current study area, the time of concentration for the sub-catchment is less than 24 hours. The "Ja Type Bx" distribution has the most intense rainfall during the second quartile of the storm duration. Applying this distribution to the published 24 hour data, allows the basin to respond with a peak discharge that would be applicable.

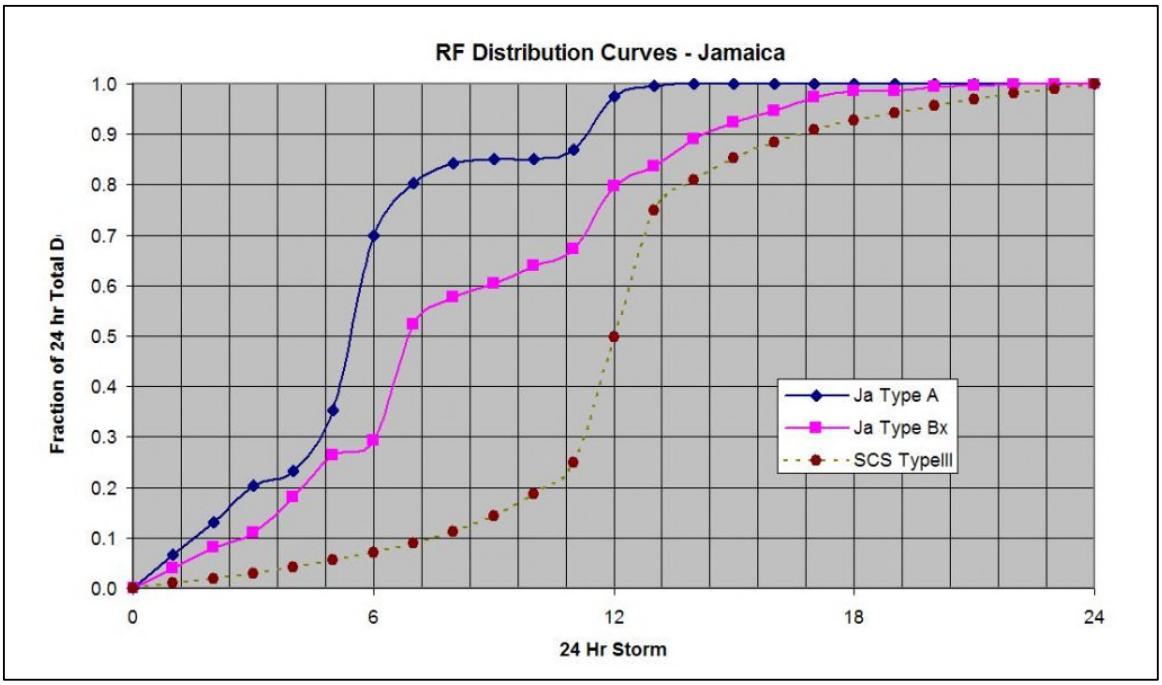

Figure 8: Design Rainfall Distributions - Jamaica

The calculation of surface runoff based on a statistical depth of rainfall for a particular return period estimate and a selected temporal distribution, is carried out for this project with the use of INFOWORKS-CS hydrologic and hydraulic modeling platform by Wallingford Software.

The US SCS model is used as implemented within INFOWORKS-CS for the computation of runoff for the sub-basins.

The SCS method is a widely accepted model for predicting storm flow volumes from rural catchments. The method is used in the USA, France, Germany, Australia and parts of Africa. It was derived for rural catchments with uniform conditions. Although some engineers have used it on urban catchments, this is not its correct application. It can be used for rural catchments contributing to an urban system. Another model should be used for the urban areas.

This is a simple runoff model that allows for variation in the runoff coefficient depending on the catchment wetness. The wetness is updated during the storm and the runoff coefficient increases as the catchment wetness increases. The catchment response is described by two parameters:

- Storage depth: the loss of rainfall that would occur in an infinitely large rainstorm, and to which losses tend as the storm continues.

If you know the curve number (CN) for a surface, then S (in metres) can be derived using the following relationship:

$S = (24.400/CN) – 0.254$

S is normally given for the AMC II antecedent moisture class. The software will automatically adjust S and hence Ia for AMC I and AMC III, if these are specified in rainfall data.

The relationships used (see Hawkins R.H. et al (1985) are:

$S_{AMC\ I} = 2.81\ S_{AMC\ II}$

$S_{AMC\ III} = 0.427\ S_{AMC\ II}$

- Catchment wetness index: used to modify the storage depth for dry or wet conditions.

6. Hydrologic Analysis and Results

The initial focus of the analysis was to establish an estimate of the existing conditions of drainage to and from the proposed development site. Clearly, such an understanding is most important in light of the fact that the site is up-stream of the Old Harbour Bay Town which is known to be highly flood prone.

The 1:100 year design storm produces an estimated total peak discharge of 41.89m³/s from the proposed site towards Old Harbour Bay.

6.1. Pre-development Drainage Analysis – Old Harbour Bay

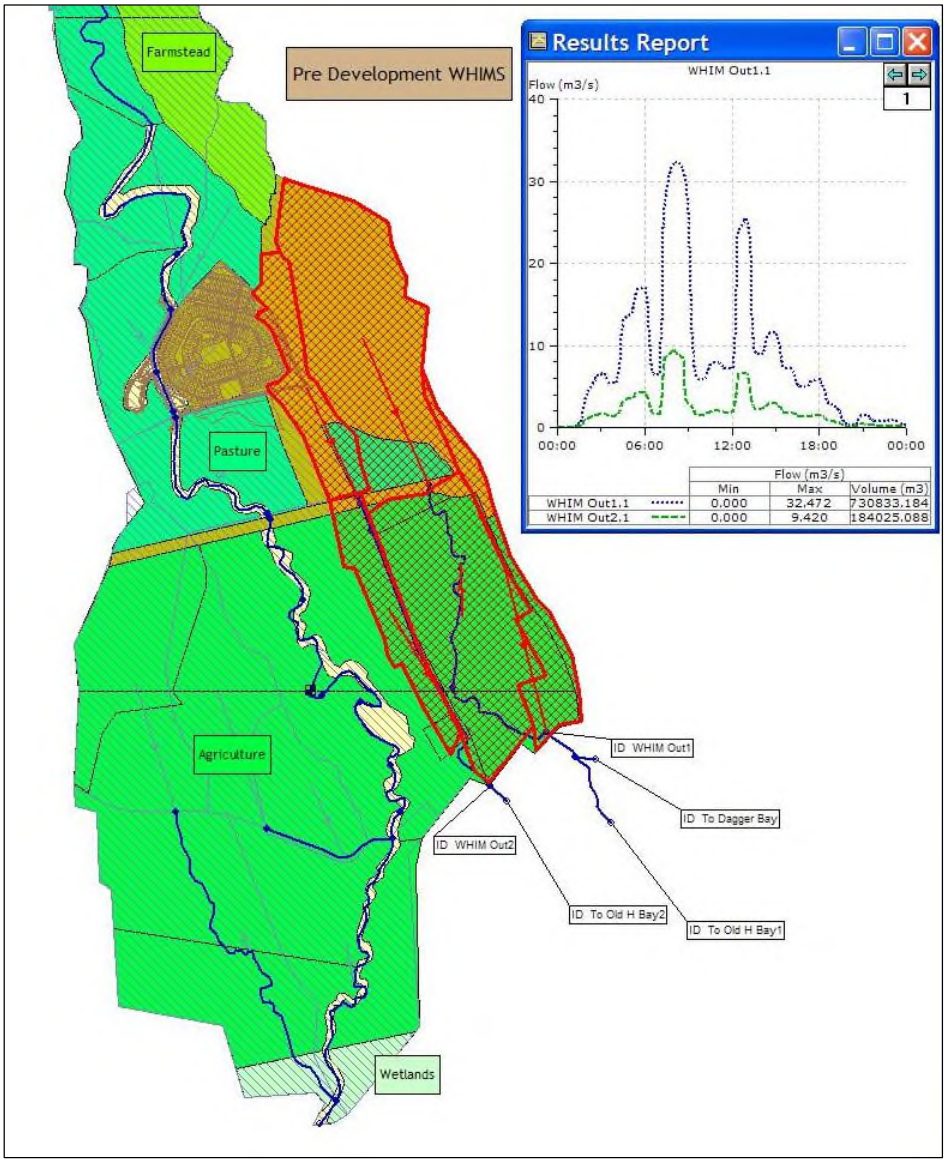

Figure 9: Pre-development 1:100yr peak discharge to Old Harbour Bay area

Of the total discharge from the proposed project site 32.47m³/s is split between flow across the main road, through the old fish ponds towards Dagger Bay and flow that continues south parallel and west of the main road, pass the primary school and through the town just to the west of the police station.

The other 9.42m³/s flows from the north western side of the town south easterly following the road into the centre of the town.

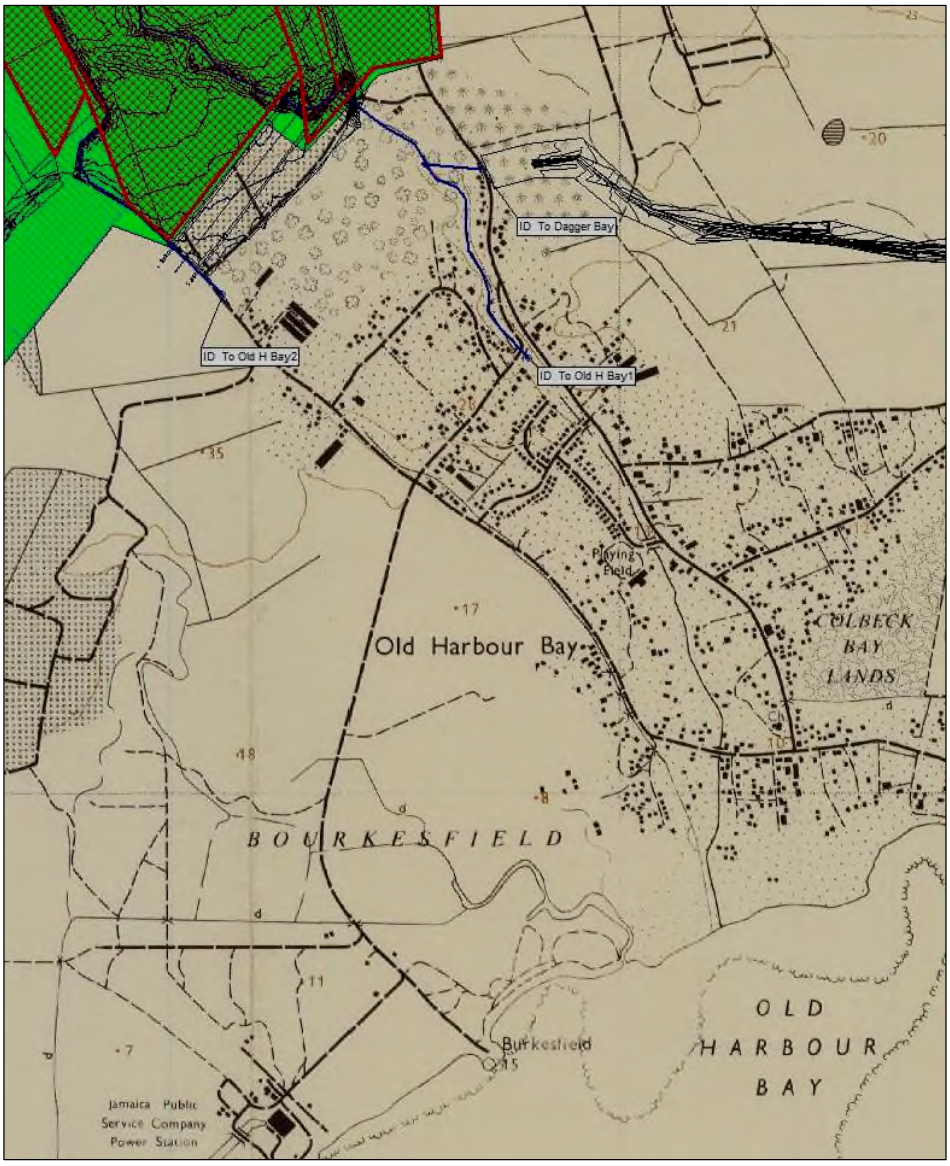

Figure 10: Impact of existing drainage condition on Old Harbour Bay

The aerial image of the current development of the Old Harbour Bay area shown in Figure 11 below, shows the significant development that has occurred in the area and highlights the drainage feature through the town.

Figure 11: Current development conditions in Old Harbour Bay

The capacities of the drains through the town are totally inadequate to convey the estimated flows even for storms with much higher return periods.

6.2. Post-development Drainage Analysis – Old Harbour Bay

To address the existing drainage challenges faced in Old Harbour Bay and recognizing that they would be exacerbated by increased peak flows from the proposed development, WHICON proposes to intercept the majority of the drainage from the development and previous drainage areas to the town and divert the storm flows to the Bower's Gully. Figure 12 below shows the reduced drainage area (hatched in red) that will continue to flow towards Old Harbour Bay.

This includes only 15 hectare of the 105 hectare of the WHIMS development. Most of the previous drainage areas north of the Toll Road, including flows from sections of the town of Old Harbour, will be diverted to Bower's Gully.

The 1:100 year design storm will produce an estimated peak discharge of 8.90m³/s from the proposed site towards Old Harbour Bay. This would provide over a 75% reduction in the peak storm flow towards Old Harbour Bay

This proposed scheme would dramatically improve the conditions in Old Harbour Bay and should be considered as a flood relief project for the town whether the proposed WHIMS development goes forward or not.

It is also intended to divert all or the greater part of the 8.90m³/s across the main road, through the old fish ponds towards Dagger Bay away from the main populated area of the town.

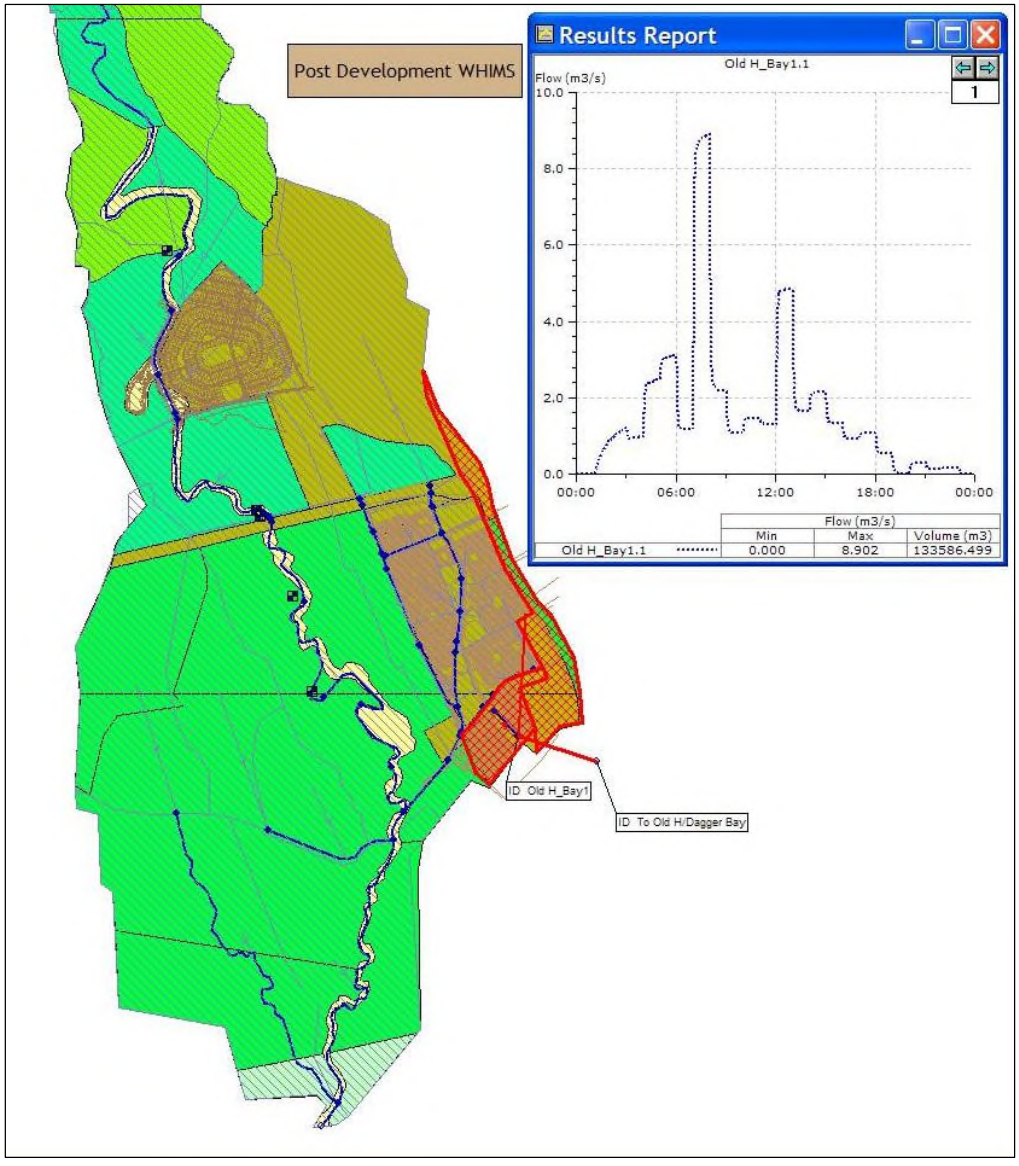

Figure 12: Post-development 1:100yr peak discharge to Old Harbour Bay area

6.3. Pre-development Drainage – Bower's Gully, Toll Road to Sea

The hydrology for the reaches of Bower's Gully from the Toll Road to the sea for the pre-development condition of the catchment, indicate that peak flows reduce in the first instance as channel storage and overbank flow occurs. The discharge hydrographs for the downstream of the three reach sections highlighted in red, also show a continuing delay in the occurrence of the peak flow. Storm flow from the lower sub-basins reach the channel and discharge to the sea before the flow from the elongated upper catchment which is delayed by over 2.5 hours.

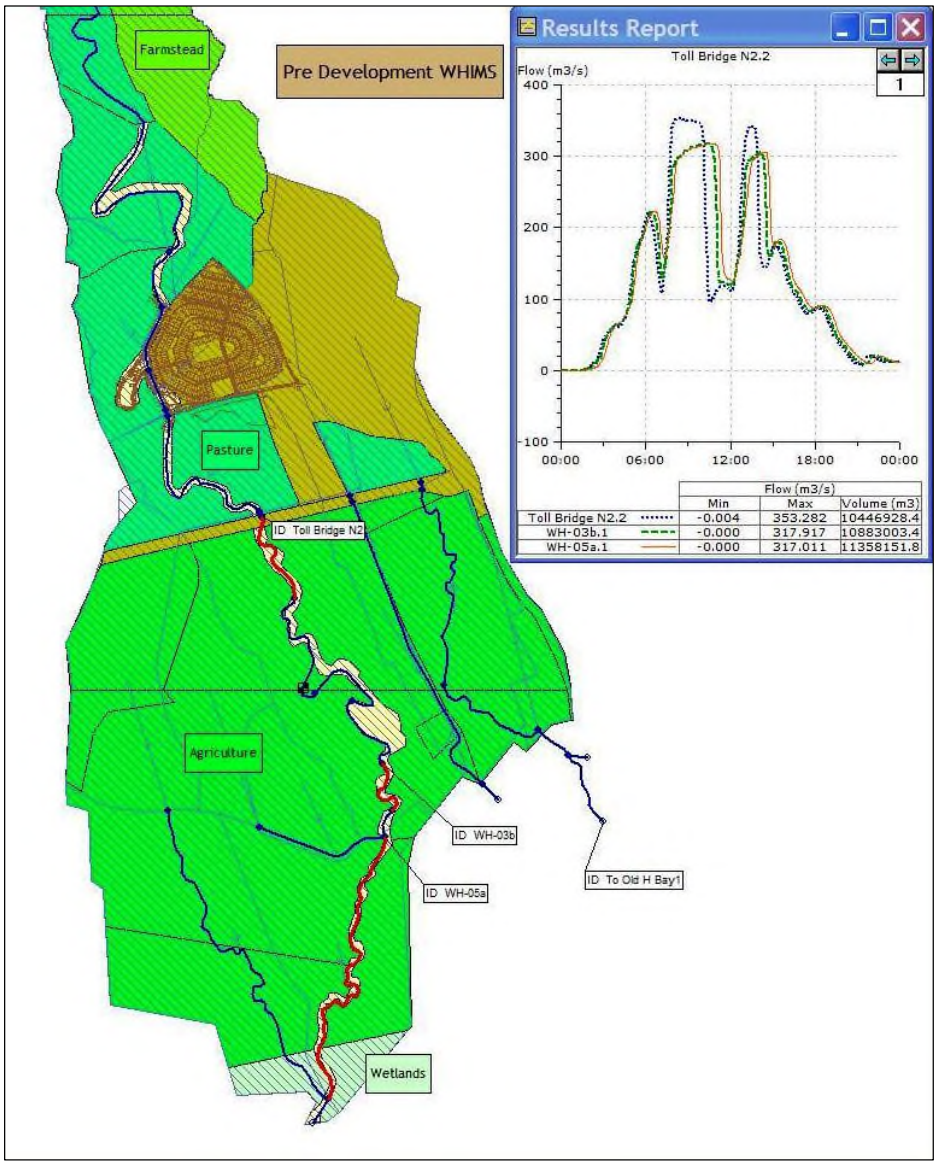

Figure 13: Pre-development 1:100yr peak discharge Toll Road to sea

6.4. Post-development Drainage – Bower's Gully, Toll Road to Sea

The hydrology for the post-development condition of the catchment, indicate that peak flows reduce in the first instance as channel storage and overbank flow occurs. The discharge hydrographs for downstream section of the three reach sections highlighted in red, shows the peak discharge from the proposed development occurring before the peak discharge in the main channel. The maximum water level at the confluence is 8.825m as indicated in the profile insert.

There is only a 3% increase in peak flow i.e., 317 to 327m³/s below the proposed confluence of the drain from the new development despite the discharge of 55m³/s from the proposed development. This is entirely because of the early discharge into the gully from the efficiently drained lower sub-basins.

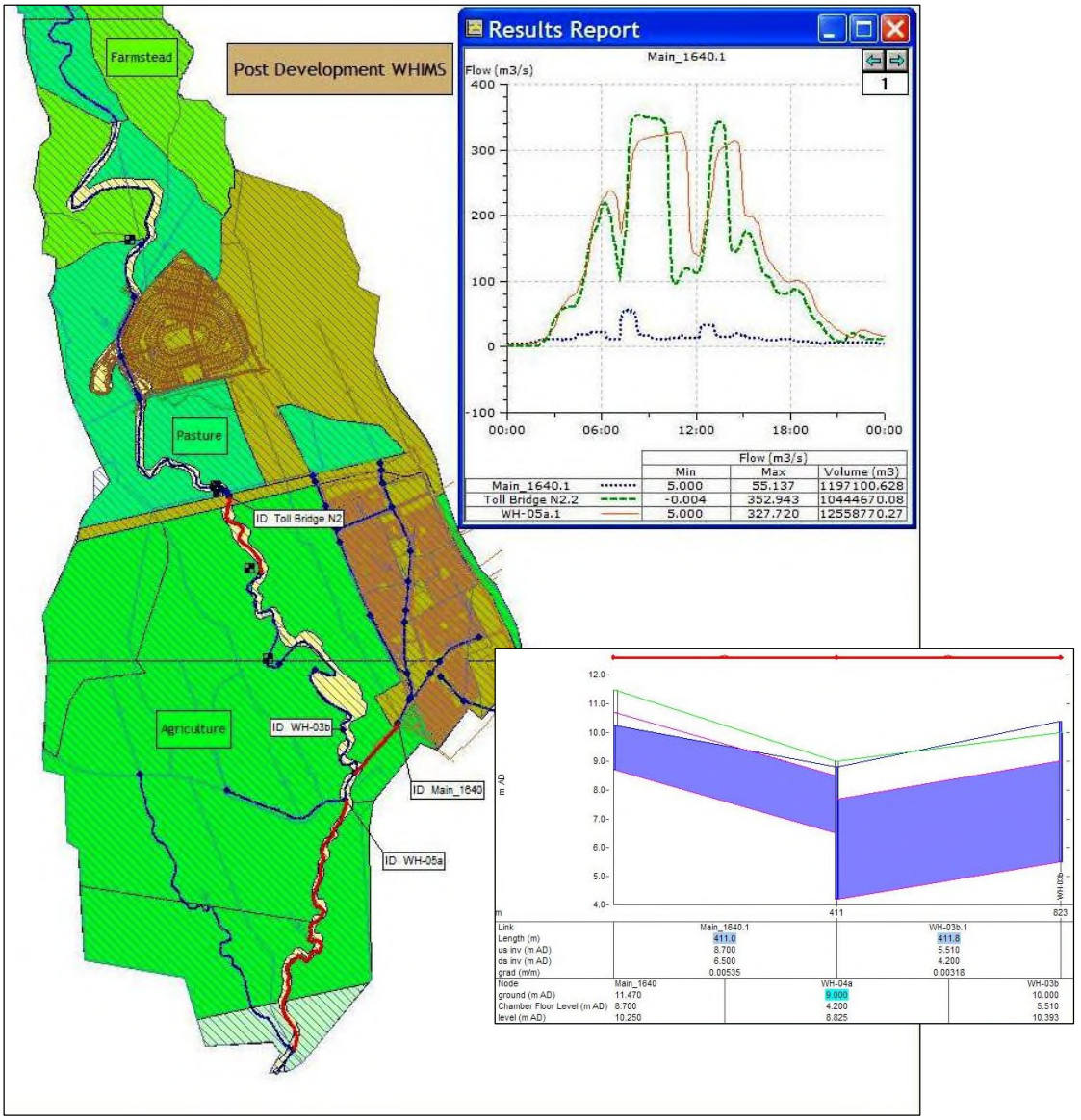

Figure 14: Post-development 1:100yr peak discharge Toll Road to sea

7. Channel Hydraulics, Inundation Mapping - WHIM to Sea

In order to evaluate the implication of the proposed diversion of the WHIM lands drainage and the main drainage from the town of Old Harbour to Bower's Gully, a detailed hydraulic model of the river channel from the proposed confluence to the sea was prepared.

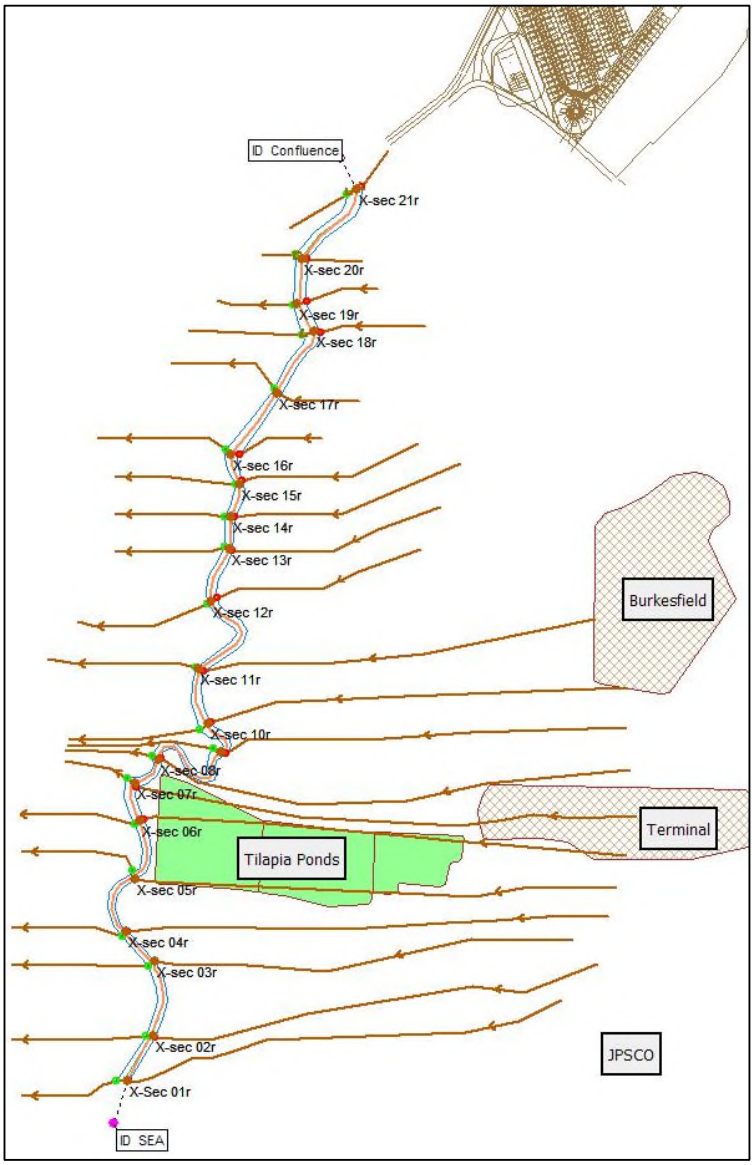

Figure 15: Lower Bower's Gully – Alignment and River Sections

7.1. Topographic Surveys and Hydraulic Data Collection

Detailed cross-sections were taken of the reach of the river to be modeled to define the channel section, left and right overbank and significant topographic features within a prescribed floodway. The extent and detail of the survey is indicated in Figure 15.

Importantly, old tilapia fish farming ponds were identified in the eastern floodway starting approximately 750m up from the sea. This structure effectively blocks the eastern overbank flow of the river. The survey also identified the sinuosity of the river and facilitated the computation of relative path lengths for the left and right overbank flow sections.

Aerial photography of the reach of the river and field trips were used to characterize the river with respect to estimates of Manning "n" values.

Anecdotal information was collected from the community on sea water levels typically experienced from storm surges and general flooding in the area.

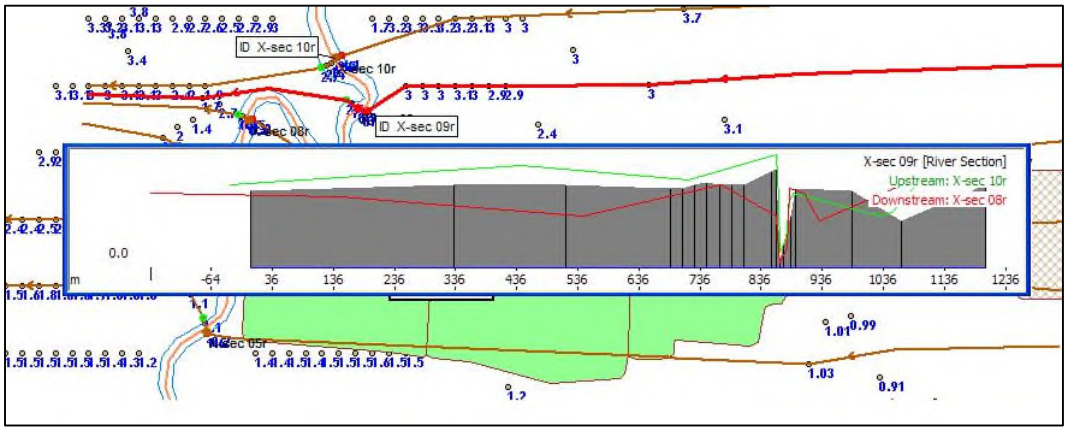

Figure 16: Typical topographic survey detail, river section

7.2. Hydraulic Results, Unsteady Flow Analysis

The output hydrograph from the previously discussed hydrology study was captured and fed as input to the unsteady flow analysis of the lower reach of the Bower's Gully. Water levels at all the river cross sections were computed.

The water level at peak flow originally indicated (Sec. 6.4) at the proposed confluence was confirmed as indicated in Figure 17, i.e., 8.19m being nominally below the recommended 8.83m AD. This was expected as the detailed survey data provided for a much wider section of overbank flow than what was used in the initial basic hydraulic study.

The lower reach of the Bower's Gully has a very limited conveyance capacity within the river channel which is also tidal flooding with a discharge of about 25m³/s . The channel is also subject to blockage from debris accumulated from upper reaches of the river.

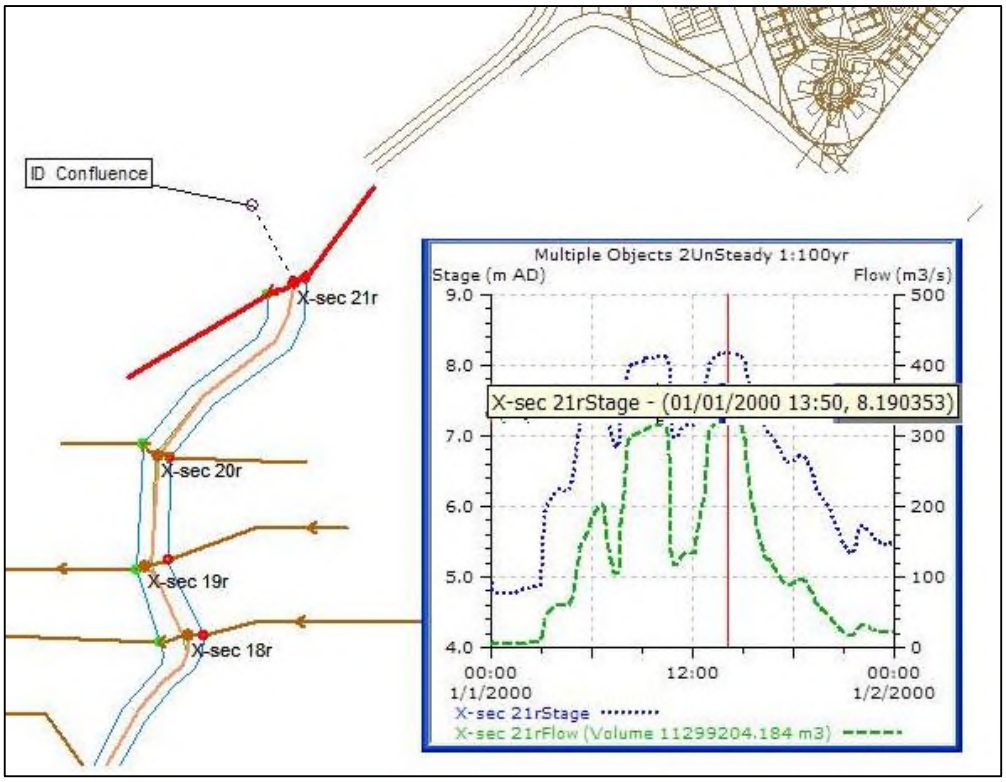

Figure 17: River stage at Confluence with WHIM diversion

The old tilapia ponds on the eastern bank of the river, is a significant restriction to overbank flow when the river is in spate. They quickly fill with water and restrict flow thereafter. The low lying lands in the communities of Burkesfield and Terminal are directly affected by the obstruction created with water level increases of up to 0.4m during significant storm events.

7.3. Inundation Mapping

The extent of inundation mapped was limited by the extent of the topographic information that was available. The predicted water levels were clearly shown flooding the western sections of the communities of Burkesfield and Terminal.

Anecdotal information confirmed that during all recent major rain storm events, flooding from the Bower's Gully was experienced in both communities with water depths in "Terminal" at some instances being over 0.5m at the peak stage.

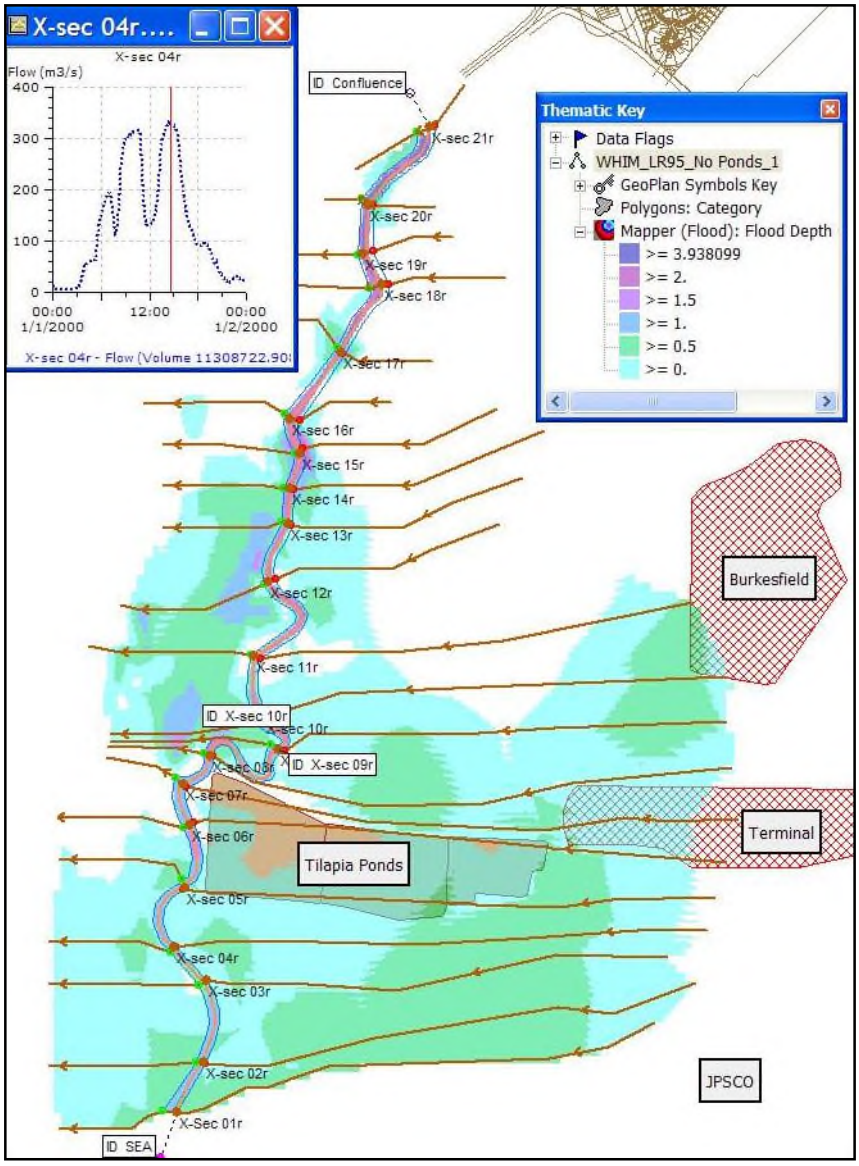

Figure 18: Flood map for lower Bower's Gully, Existing Situation

8. Recommendation for a floodway - Lower Bower's Gully

Based on the findings of the hydraulic analysis of the lower reach of the Bower's Gully, it would seem that an inexpensive intervention could alleviate most of the river related flooding experienced in the communities of Burkesfield and Terminal.

These communities especially the low lying "Terminal" will always be occupied because of the over-riding economic factors. The land is very fertile, access to the area is good, the primary economic activity of fishing in the area is capable of supporting a growing community and farmers are unwilling to live away from their fields for fear of losses due to praedial larceny.

The full detail of the proposed intervention is outside of the scope of this report. There are drainage issues that need to be addressed throughout the entire Old Harbour Bay community. The benefit of the previously discussed proposal to divert traditional storm flows from the area will greatly relieve some of the challenges.

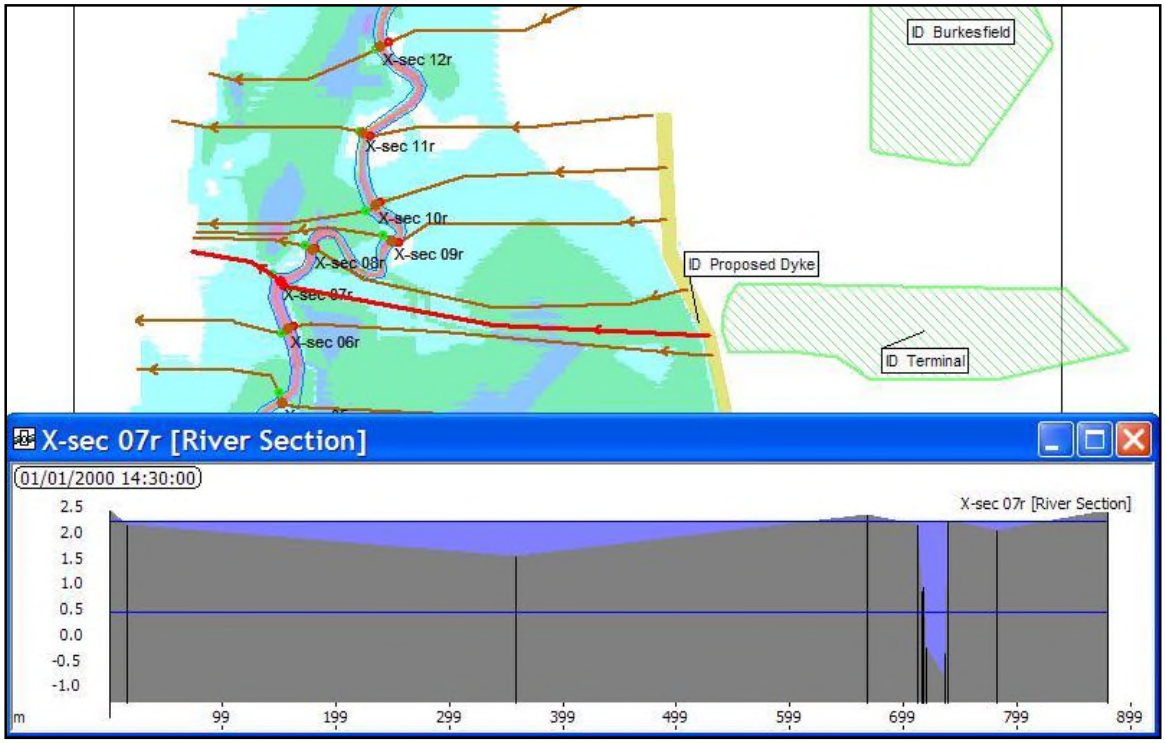

Figure 19: River Section "X-sec 07r" highlighted showing dyke containing river

8.1. Proposed Floodway

The old tilapia ponds must be removed in particular, the embankments that run east to west. A dyke is proposed running parallel to the Bower's Gully approximately 600m to the east of "Bundung Bridge". The dyke would extend from the sea inland for approximately 800m and would have a height of 1.5m. Material to construct the dyke could be taken from the embankments of the old ponds and also from excavation of a drain to the immediate east of the proposed dyke.

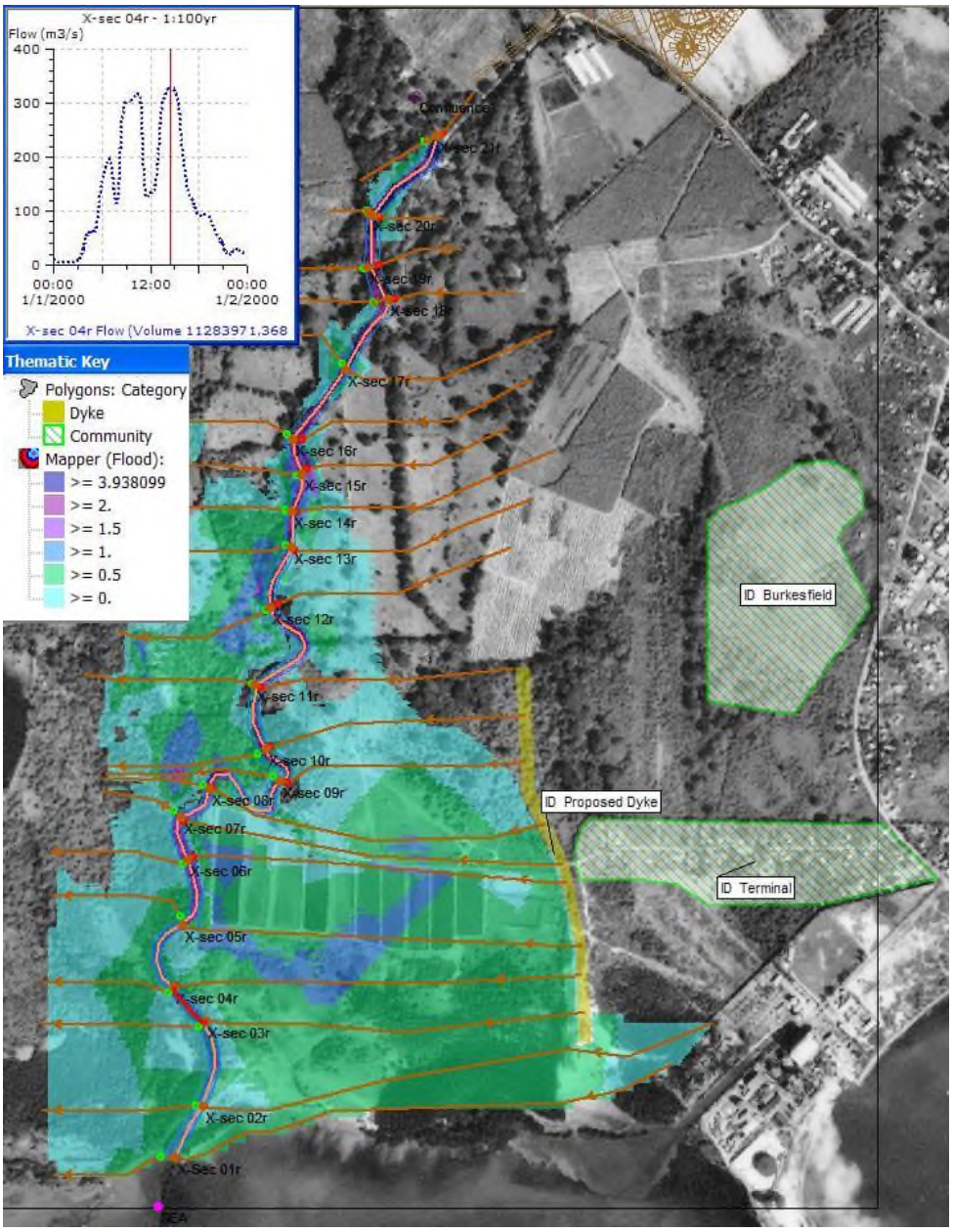

Figure 20: Dyke and removal of ponds prevents inundation - Terminal

It is reported that much of the land in the area is owned by the JPSCO.

The overbank features of the Bower's Gully were modified along with the ground model to reflect the proposal and evaluated. The resulting elimination of flooding demonstrated in the model could clearly provide a significant improvement to conditions in the communities of Burkesfield and Terminal.