



Orange-Senqu River Basin

Orange-Senqu River Commission Secretariat
Governments of Botswana, Lesotho, Namibia and South Africa

UNDP-GEF
Orange-Senqu Strategic Action Programme
(Atlas Project ID 71598)

Database

**Research project on environmental flow
requirements of the Fish River and the
Orange-Senqu River Mouth**

Technical Report 36
Rev 0, 30 October 2013



UNDP-GEF
Orange-Senqu Strategic Action Programme

Database

Research project on environmental flow requirements of the Fish
River and the Orange-Senqu River Mouth

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This document has been issued and amended as follows:

Revision	Description	Date	Signed
0	Initial draft for review	30 Oct 2013	DL, PW

Project executed by:



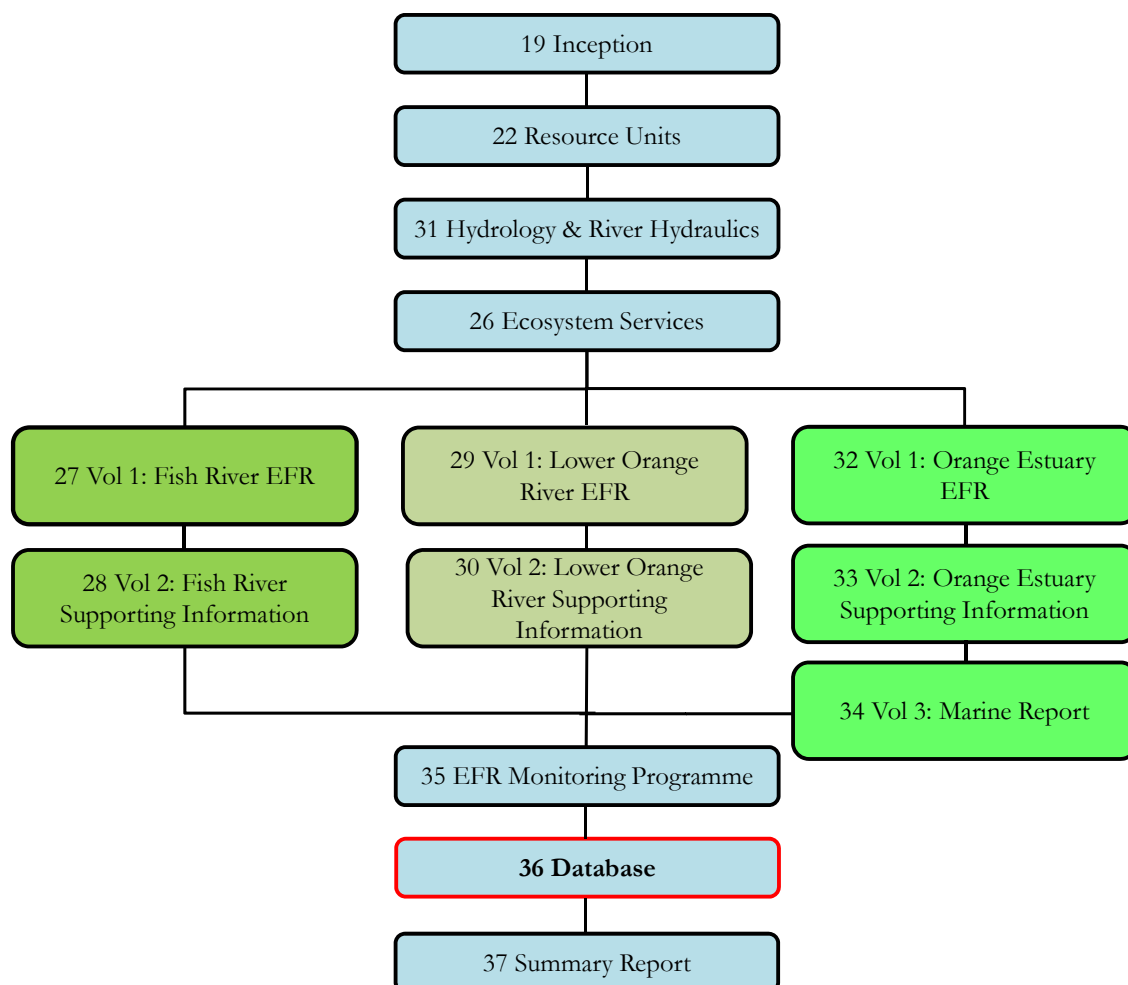
Report list

A list of the Technical Reports that form of this study is provided below. A diagram illustrating the linkages between the reports is also provided.

Technical Report No	Report
19	Inception Report, Research project on environmental flow requirements of the Fish River and the Orange-Senqu River Mouth
22	Delineation of the Study Area – Resource Unit Report, Research project on environmental flow requirements of the Fish River and the Orange-Senqu River Mouth
26	Consequences of Scenarios on Ecosystem Services, Research project on environmental flow requirements of the Fish River and the Orange-Senqu River Mouth
27	River EFR assessment, Volume 1: Determination of Fish River EFR Research project on environmental flow requirements of the Fish River and the Orange-Senqu River Mouth
28	River EFR assessment, Volume 2: Fish River EFR, supporting information Research project on environmental flow requirements of the Fish River and the Orange-Senqu River Mouth
29	River EFR assessment, Volume 1: Determination of the lower Orange River EFR Research project on environmental flow requirements of the Fish River and the Orange-Senqu River Mouth
30	River EFR assessment, Volume 2: Lower Orange River EFR, supporting information Research project on environmental flow requirements of the Fish River and the Orange-Senqu River Mouth
31	River and Estuary EFR assessment, Hydrology and River Hydraulics Research project on environmental flow requirements of the Fish River and the Orange-Senqu River Mouth
32	Estuary and Marine EFR assessment, Volume 1: Determination of Orange Estuary EFR Research project on environmental flow requirements of the Fish River and the Orange-Senqu River Mouth
33	Estuary and Marine EFR assessment, Volume 2: Orange Estuary EFR: Supporting Information Research project on environmental flow requirements of the Fish River and the Orange-Senqu River Mouth
34	Estuary and Marine EFR assessment, Volume 3: Assessment of the Role of Freshwater Inflows in the Coastal Marine Ecosystem Research project on environmental flow requirements of the Fish River and the Orange-Senqu River Mouth
35	EFR monitoring programme, Research project on environmental flow requirements of the Fish River and the Orange-Senqu River Mouth
36	Database, Research project on environmental flow requirements of the Fish River and the Orange-Senqu River Mouth

Technical Report No	Report
37	Summary Report, Research project on environmental flow requirements of the Fish River and the Orange-Senqu River Mouth

Bold indicates current report.



Acknowledgements

The following persons and institutions are gratefully acknowledged for assisting with information presented in this report:

Project manager

Christoph Mor

Electronic data collation:

Shael Koekemoer

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Abbreviations

<i>ASCII</i>	<i>American Standard Code for Information Interchange</i>
<i>csv</i>	<i>comma-separated value</i>
<i>EcoStatus</i>	<i>Ecological Status</i>
<i>EFR</i>	<i>Environmental flow requirement</i>
<i>GIS</i>	<i>Geographic Information System</i>
<i>JPEG</i>	<i>Joint Photographic Experts Group</i>
<i>ORASECOM</i>	<i>Orange-Senqu River Commission</i>
<i>WIS</i>	<i>ORASECOM Water Information System, data and information platform</i>

1. Background

A number of geo-located data sets were generated during the Project. The terms of reference of the project required that these data sets were stored in a database format and made available through an on-line interface. The interface of choice was the Water Information System Platform (WISP) – an online geographical data storage system run under the auspices of Orange-Senqu River Commission (ORASECOM), accessed under the web address: <http://wisp.orasecom.org>.

A dedicated web page has been created on the ORASECOM Water Information System (WIS) to provide access to data generated within the e-flows project::

[http://wis.orasecom.org/content/study/UNDP-GEF/Estuary Environmental Flows/](http://wis.orasecom.org/content/study/UNDP-GEF/Estuary%20Environmental%20Flows/)

Additionally, an interactive base map has been created, presenting all geographical layers stored in the WIS pertaining to this project. The base map can be assessed through the project data page, but also directly through: [http://wis.orasecom.org/content/study/UNDP-GEF/Estuary Environmental Flows/EFlowsMap.htm](http://wis.orasecom.org/content/study/UNDP-GEF/Estuary%20Environmental%20Flows/EFlowsMap.htm)

1.1 Objectives

The overall objective of this component is to provide a systematically organised set of spatial data relevant to the project in order to support activities of specialists during the duration of the project and for the use by catchment management organisations after project completion.

1.2 Report structure

Chapter 1: Background

This chapter provides general background information pertaining to the project task.

Chapter 2: Organisation of the database

Provides a general description and outline of the database and includes the general characteristics of the project data and character of the data storage platform

Chapter 3 – 5: User Manual

The following three chapters is a basic user manual and cover the following aspects:

- Chapter 3: Use of the Environmental flow requirement project web page on the WIS.
- Chapter 4: Using the environmental flow requirement project map on the WIS.
- Chapter 5: Using the geographical and attribute data independently of WIS.

2. Organisation of the database

2.1 Rationale behind the adopted database organisation

The organisation of the Environmental flow requirement (EFR) database has been determined on the basis of analyses of:

- Characteristics of project data;
- Intended use of data;
- Character of data storage and retrieval platform.

2.1.1 *Characteristics of project data*

The characteristics of the project data is outlined below.

All data relate to the following geographical entities:

- EFR core sites (a relatively narrow stretches of the Fish and Orange rivers, approximated by point geographic coordinates);
- Point measurement sites other than EFR sites;
- River cross-sections;
- Sub-catchment outlets;
- River reaches;
- Orange River estuary and its parts;

The number of geographical entities is relatively low. There are three core EFR sites, ~ 20 sampling points other than EFR sites, 12 river cross-sections, 17 subcatchment outlets and six river reaches.

Data are of the following types:

- one-off and spatially and temporary irregular campaign-based measurements (such as fish, or macro-invertebrate surveys);
- tables (mostly representing data of various type combined in the process of calculating ecosystem status indices);
- time series (such as river discharges or rainfall);
- measurement site and campaign metadata (photos, graphs, description of instruments, model parameters).

Data belong to the following distinct thematic categories:

- hydrological data;

- water quality and sediment data;
- raw ecological data;
- Ecological Status (EcoStatus) assessment indices;
 - under current conditions;
 - under scenarios.

Data differ in scope:

- Generic data are useable out of scope of the e-flows project (e.g. results of fish or bird surveys);
- Specific data are related to the process of determination of EFR, and are of limited use out of the scope of the e-flows project (e.g. a Fish Response Assessment Index).

2.2 Intended use of data

In our opinion, datasets generated within the project will be primarily used within thematic context (e.g. hydrological data, Ecological status assessment indices) and their scope (generic/specific). Considering these, potential users of data will want to access specific thematic datasets.

2.3 Character of data storage platform

As agreed with the Client, the project's database is to be hosted on ORASECOM's Water Information System, or WIS. That platform is based on OpenGIS GeoServer application. The nature of the WIS is such that in principle it facilitates access to and visualisation of spatial datasets but does not easily accommodate complex attribute data.

2.4 Adopted organisation of the project database

In view of the data characteristics outlined above, we have organised the database by thematic datasets. In that, we have created individual geographical layers for distinct thematic datasets. For example, we have created a geographical layer representing macroinvertebrate sampling points – a dataset falling into Raw Ecological Data category. Other datasets under the same category, for example, diatom sampling points, have been stored in separate geographical layer. The 'EFR sites' layer, is a notable exception from that scheme, as it stores a specific category of locations for which data from several thematic categories are available. Additionally, we have separated the Orange River estuary datasets from Orange River and Fish/Orange River datasets. The latter was dictated by the fact that the thematic data for river sites and estuary sites had different character and were organised in a different way.

The geographical layers are stored as ESRI shapefiles with attribute tables. The attribute table of a layer stores basic attribute data such as name and short description, and/or a reference to an external file(s). The external files contain tabular data, metadata describing the tabular data (e.g. graphs presenting time series or photos of measurement site). Files with tabular data are stored

either in American Standard Code for Information Interchange (ASCII) text format, or in MS Excel format, depending on the complexity of data they contain. Graphs and photos are stored in Joint Photographic Experts Group (JPEG) format.

Within this database, generic data, which are meant to be re-used in other applications, are provided in raw format. For example, results of diatom surveys are presented as diatom counts at a site. Specific data are provided with their context. For example Fish Response Assessment Index is presented within a spreadsheet that includes all factors used in its calculation.

Physically, Geographic Information System (GIS) layers are stored within the WIS GeoServer environment. The tabular data are stored in the directory tree presented in Table 1. Graphs and figures are stored in the directory tree shown in Table 2, while photos are stored in the directory tree shown in Table 3.

The project data also include all project documents (reports) as well as a number of ready-made maps generated for presentation of project area and location of measurement sites. These elements are not sensu-stricto geo-located. They were, however, included in the Project database, in the directory tree presented in Table 4.

Both the WIS GeoServer base map, and the project web page support the above organisation for easy retrieval of tables and graphs. The WIS GeoServer base map facilitates retrieval of data for an individual geographical entity, while the web page provides easy retrieval by dataset.

Table 1. Organisation of tabular attribute data of the e-flows project

<i>Thematic category</i>		
<i>GIS layer</i>	<i>Data Set</i>	<i>Physical location of file*</i>
EcoStatus Assessment Indices		
EFR sites	Ecological Importance and Sensitivity	/Ecostatus_Assessment_Indices/Ecological_Importance_and_Sensitivity/
	EcoStatus level 4	/Ecostatus_Assessment_Indices/EcoStatus_level_4/
	Fish Response Assessment Index	/Ecostatus_Assessment_Indices/Fish_Response_Assessment_Index/
	Geomorphological Driver Assessment Index	/Ecostatus_Assessment_Indices/Geomorphological_Driver_Assessment_Index/
	Index of Habitat Integrity	/Ecostatus_Assessment_Indices/Index_of_Habitat_Integrity/
	Macroinvertebrate Ecological Traits	/Ecostatus_Assessment_Indices/Macroinvertebrate_Ecological_Traits/
	Macroinvertebrate Response Assessment Index	/Ecostatus_Assessment_Indices/Macroinvertebrate_Response_Assessment_Index/
	Physico-chemical Driver Assessment Index	/Ecostatus_Assessment_Indices/Physico-chemical_Driver_Assessment_Index/
	Riparian Vegetation Response Assessment Index	/Ecostatus_Assessment_Indices/Riparian_Vegetation_Response_Assessment_Index/
Scenario EcoStatus Assessment		
EFR sites	EcoStatus level 4	/Scenario_Ecostatus_Assessment/EcoStatus_level_4/
	Fish Response Assessment Index	/Scenario_Ecostatus_Assessment/Fish_Response_Assessment_Index/
	Geomorphological Driver Assessment Index	/Scenario_Ecostatus_Assessment/Geomorphological_Driver_Assessment_Index/
	Macroinvertebrate Ecological Traits	/Scenario_Ecostatus_Assessment/Macroinvertebrate_Ecological_Traits/
	Macroinvertebrate Response Assessment Index	/Scenario_Ecostatus_Assessment/Macroinvertebrate_Response_Assessment_Index/
	Physico-chemical Driver Assessment Index	/Scenario_Ecostatus_Assessment/Physico-chemical_Driver_Assessment_Index/
	Riparian Vegetation Response Assessment Index	/Scenario_Ecostatus_Assessment/Riparian_Vegetation_Response_Assessment_Index/
	Riverine Fauna Response	/Scenario_Ecostatus_Assessment/Riverine_Fauna_Response/
Raw Ecological Data		

<i>Thematic category</i>		
<i>GIS layer</i>	<i>Data Set</i>	<i>Physical location of file*</i>
Diatoms	Diatom survey of Fish and Orange Rivers	/Raw_Ecological_Data/Diatoms/
Macro-invertebrates	Macroinvertebrates survey of Fish and Orange Rivers	/Raw_Ecological_Data/Macroinvertebrates/
Fish	Fish survey of Fish and Orange Rivers	/Raw_Ecological_Data/Macroinvertebrates/
Estuary Macroinvertebrates	Macroinvertebrates survey in the estuary	/Raw_Ecological_Data/Estuary_Macroinvertebrates/
Estuary Fish	Fish survey in the estuary	/Raw_Ecological_Data/Estuary_Fish/
Estuary Birds	Bird survey in the estuary	/Raw_Ecological_Data/Estuary_Birds/
Estuary Macrophytes	Macrophytes survey in the estuary	/Raw_Ecological_Data/Estuary_Macrophytes/
Estuary Macroalgae	Macroalgae (including diatoms) survey in the estuary	/Raw_Ecological_Data/Estuary_Macroalgae
Hydrological Data		
Hydrological model nodes	Disaggregated Daily Flows (modeled)	/Hydrological_Data/present_day_disaggregated_daily_flows/
	Monthly Flows (modeled)	/Hydrological_Data/present_day_monthly_flows/
	Monthly Rainfall Input to Model	/Hydrological_Data/monthly_rainfall_input_to_model/
	Monthly Scenario Flows	/Hydrological_Data/scenario_monthly_flows/
	Disaggregated Daily Scenario Flows	/Hydrological_Data/scenario_disaggregated_daily_flows/
Hydrological model dams	Pitman Model Parameters	/Hydrological_Data/pitman_model_parameters/
	Scenario Monthly Flows	/Hydrological_Data/scenario_monthly_flows/
	Monthly Flows (modeled)	/Hydrological_Data/present_day_monthly_flows/

<i>Thematic category</i>		
<i>GIS layer</i>	<i>Data Set</i>	<i>Physical location of file*</i>
River cross-sections	Stage-discharge relationship	/Hydrological_Data/stage_discharge_relationship/
Water Management Models	Results of WReMP Fish River Water Management Model	Hydrological_Data/WReMP_Fish_River_Water_Management_Model/
	Results of WRMP Integrated Vaal River System Model	Hydrological_Data/WRMP_Integrated_Vaal_River_System_Model/
Water Quality and Sediment Data		
Estuary Sediment	Sediment surveys in the estuary	Water_Quality_and_Sediment_Data/Estuary_Sediment/
Estuary Water Quality	Water quality surveys in the estuary	Water_Quality_and_Sediment_Data/Estuary_Water_Quality/

* Relative to [http://wis.orasecom.org/content/study/UNDP-GEF/Estuary Environmental Flows/](http://wis.orasecom.org/content/study/UNDP-GEF/Estuary%20Environmental%20Flows/)

Table 2. Organisation of overview figure files

GIS layer		
Category	Data set	Physical location of files
EFR sites		
EcoStatus Assessment Indices	Index of Habitat Integrity	/EcoStatus Assessment Indices/Index of Habitat Integrity/
Hydrological model nodes		
Hydrological data	Present day disaggregated daily modelled flows	/Figures/present_day_disaggregated_daily_flows/
	Present day monthly modelled flows	/Figures/present_day_monthly_flows/
	Monthly Rainfall Input to Model	/Figures/monthly_rainfall_input_to_model/
	Monthly Scenario Flows	/Figures/monthly_scenario_flows/
	Disaggregated Daily Scenario Flows	/Figures/disaggregated_daily_scenario_flows/
	Pitman Model Parameters	/Figures/pitman_model_parameters/
River cross-sections		
Hydrological data	Stage-discharge relationship	/Figures/stage_discharge_relationship/

* Relative to <http://wis.orasecom.org/content/study/UNDP-GEF/Estuary Environmental Flows/>

Table 3. Organisation of photographs

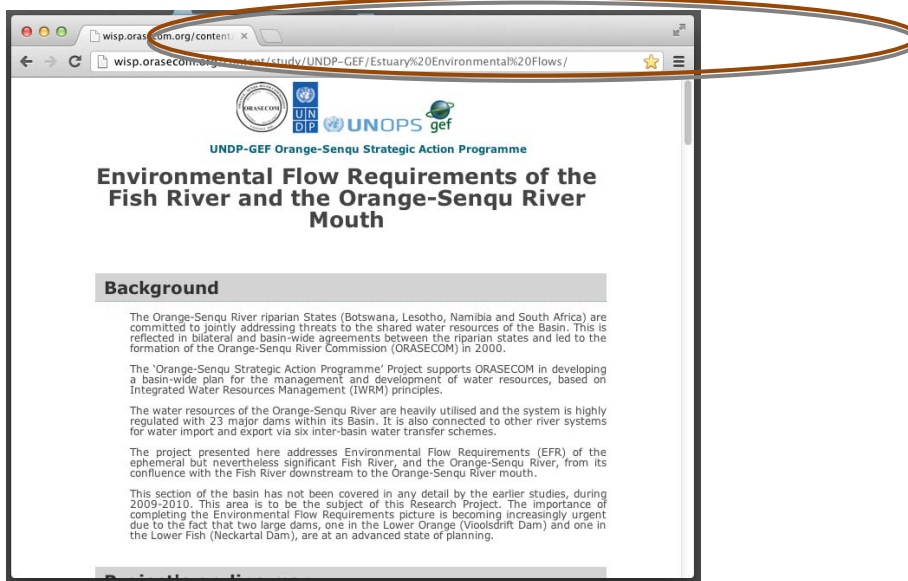
GIS layer	Category	Data set	Physical location of files
River cross-sections	Hydrological data	Stage-discharge relationship	/Photos/

Table 4. Organisation of non-geolocated documents

Category	Physical location of files
Documents	/Documents/
Maps	/Maps/

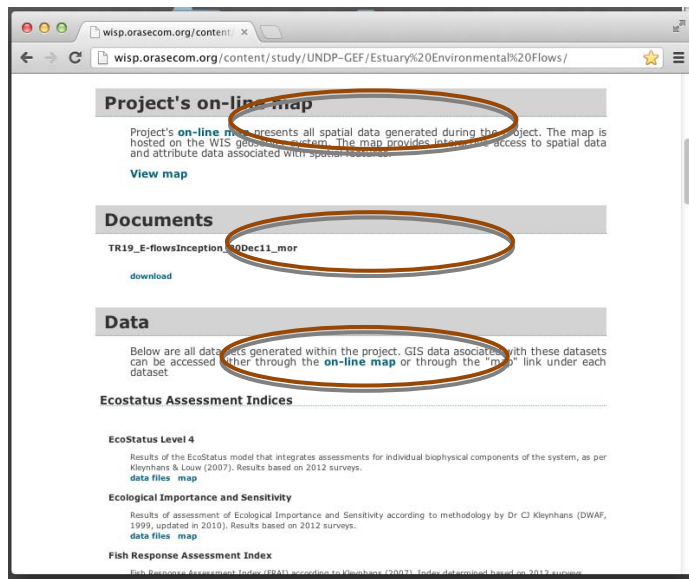
3. Use of the e-flow web page on the WIS

The E-flows Research Project web page has been created with the purpose of enabling access to the data sets generated within the Project. The page was designed to be simple and intuitive. It is available at [http://wis.orasecom.org/content/study/UNDP-GEF/Estuary Environmental Flows/](http://wis.orasecom.org/content/study/UNDP-GEF/Estuary%20Environmental%20Flows/)



The web page contains the following sections:

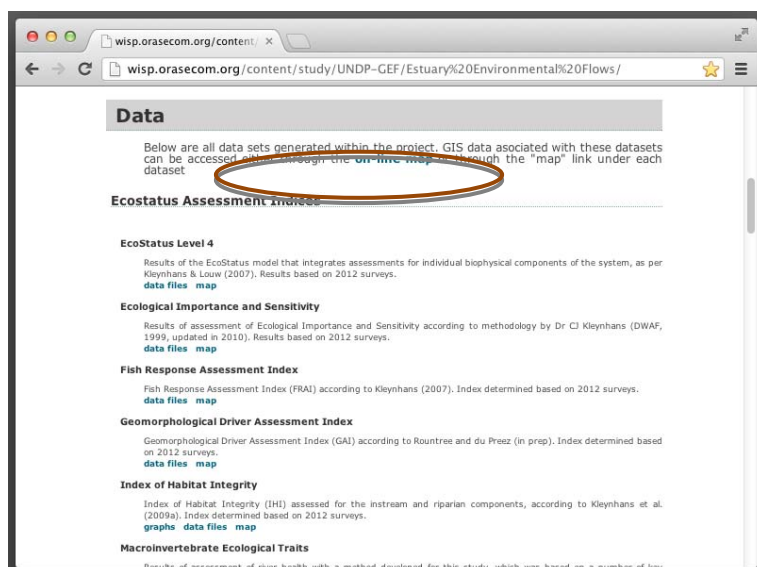
- **Background:** Presents background information about the project.
- **Project on-line map:** Provides access to all geographical layers.
- **Documents:** Provides links to project reports.
- **Data:** Provides links to external tabular data, graphs, photos and a map showing the individual geographical layer.
- **Maps:** Provides links to ready-made project maps.



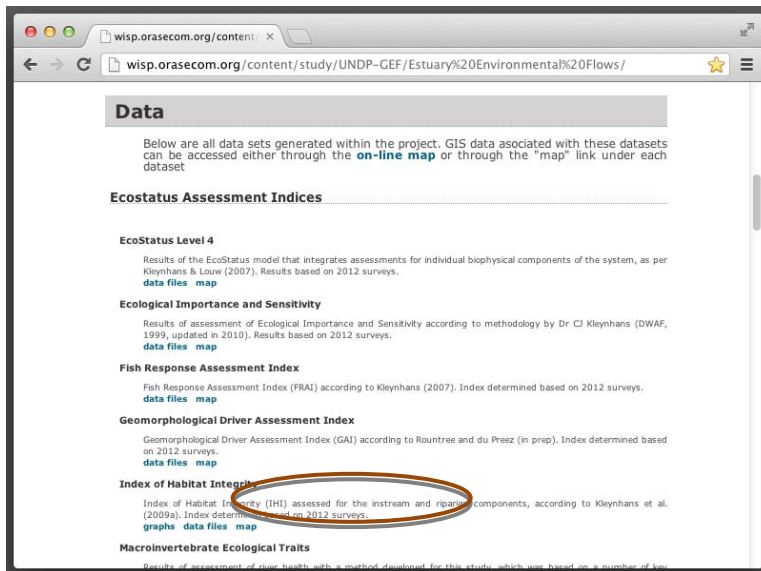
3.1 Use of the data section of the page

The Data section is organised into sub-sections reflecting data categories:

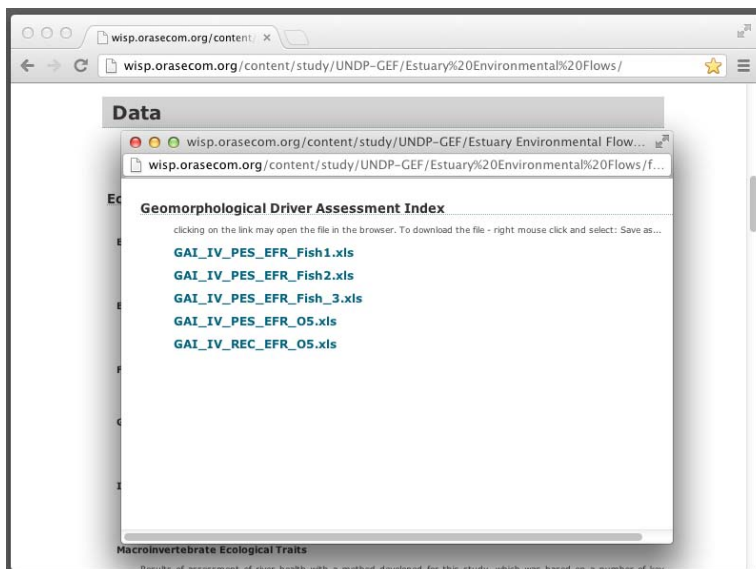
- EcoStatus assessment indices (under current conditions);
- Scenario EcoStatus assessment indices (under simulated scenarios);
- Hydrological data;
- Water quality and sediment data;
- Raw ecological data;
- Metadata.



For each of the categories available data sets are listed. For each data set, a short description is given of what the data set contains, and below that, links to external tabular attribute data ('data file'), graphs ('graphs') or photos ('photos') are provided. Also provided is the link to a WIS GeoServer map ('map') showing location of the geographical entities for which the given data set is relevant.



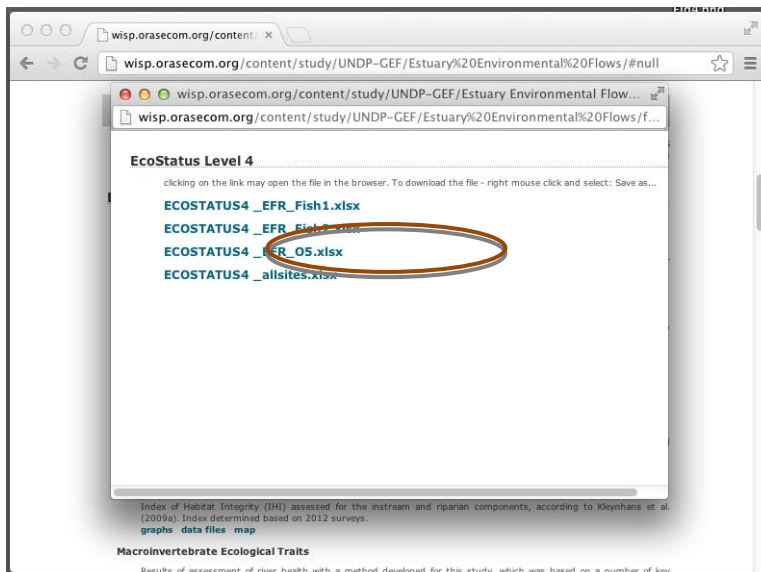
Clicking on the 'data files' link opens another browser window that contains list of external attribute data files available for the given data set. For example, clicking on 'data files' under Geomorphological Driver Assessment Index will open the following window:



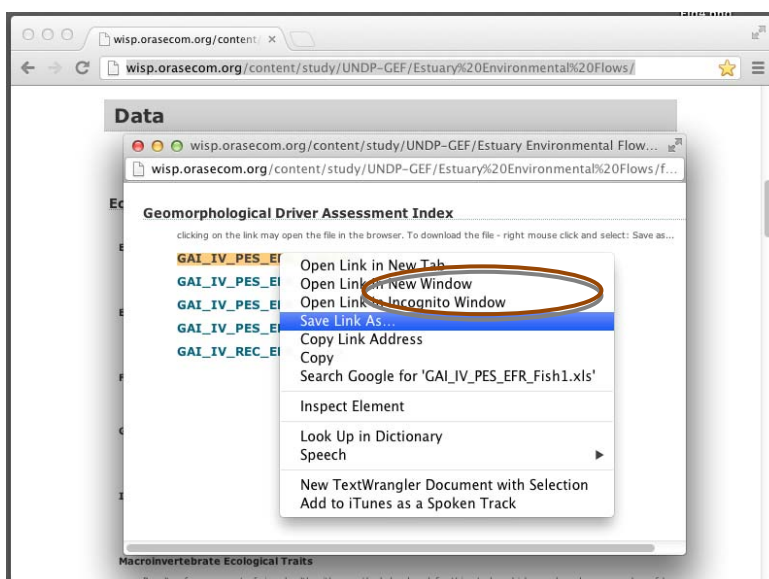
Names of these files decode their contents. First part of the file name represents variable stored in the file. In the above example, 'GAI_IV_PES' denotes Geomorphological Driver Assessment

Index IV, Present Ecological State. The second part of the file name represents location: e.g. 'EFR_Fish1' denotes site EFR Fish 1.

Tabular external attribute data files are, however, organised in two ways. For most of the features, there are individual tabular data files for each of the locations for which the data are available. For some data sets, where it is expedient to do so, tabular data are also stored in a single file for all locations. In such a case, the second part of the file name will be 'allsites', as for example for the EcoStatus level 4 index:

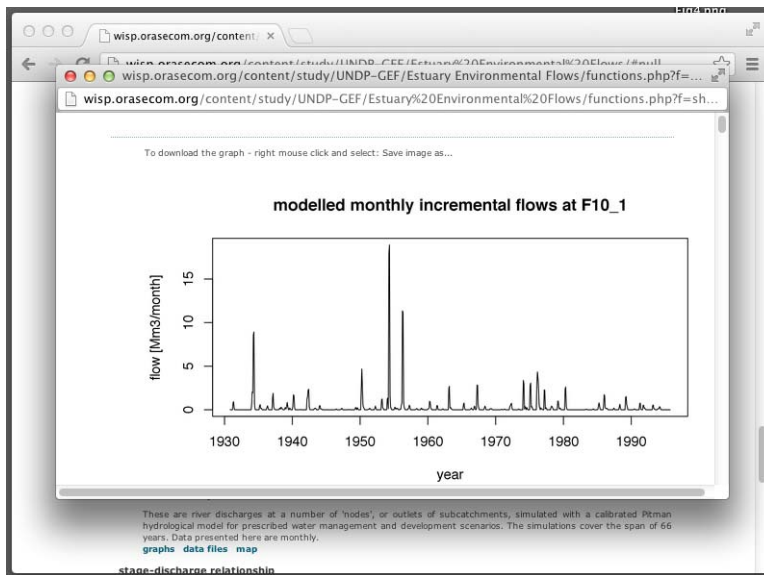


To download an external attribute data file, user has to right-mouse click on the link and select 'Save file as...' from the contextual menu (the exact command may differ depending on browser and operating system).



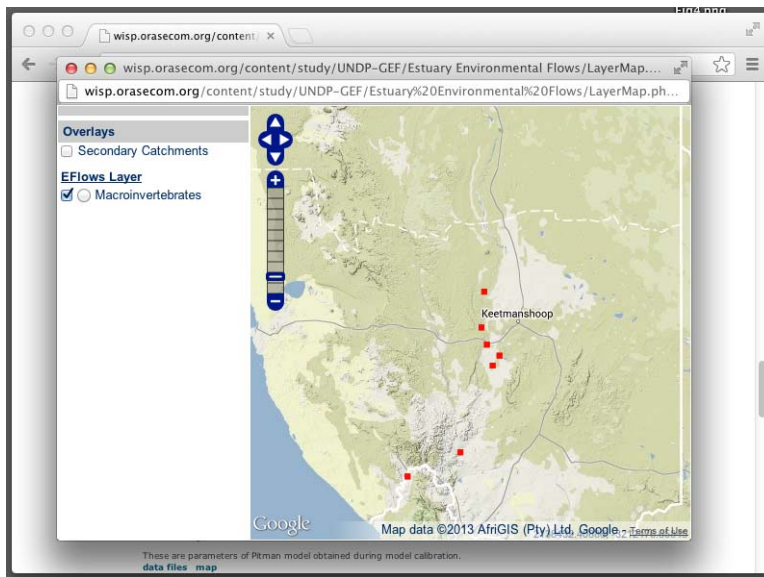
Alternatively, the user may click on the file link, and the file will be opened in the browser window (if browser supports reading the given file format), or the user will be prompted for downloading the file.

After clicking on the 'Graph' link for a dataset, a set of graphs available for given dataset will appear in a new browser window. For example, clicking on 'Graphs' under Present Day Monthly Flow, will open the following window:



To download the figure, user has to right-mouse click on the figure appearing in the browser window and select 'Save file as...' from the contextual menu.

Clicking on the 'Map' link opens another browser window which shows a background map (Google physical map), selected general GIS layers (Orange-Senqu River sub-catchments) and shows features (entities) that are relevant to the selected data set. For example, clicking on the 'Map' link under Macro-invertebrates dataset will open the following window:



This maps show location of all points for which Macro-invertebrates data were collected. This map can be used in the same way as the main project map, the use of which is described in the next section.

3.2 Use of the documents, maps and metadata section of the page

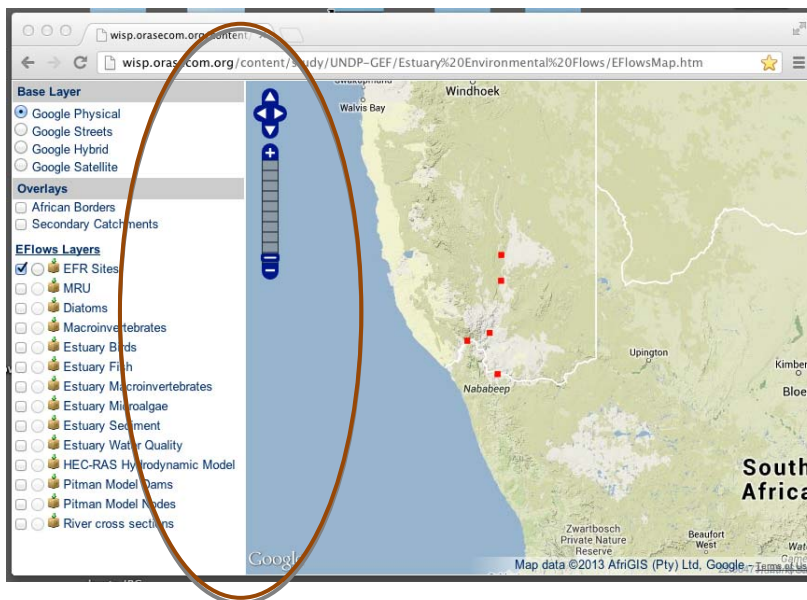
The Documents and Maps sections contain plain links to downloadable files. Files can be downloaded upon clicking on these links.

4. Using the e-flows project map on the WIS

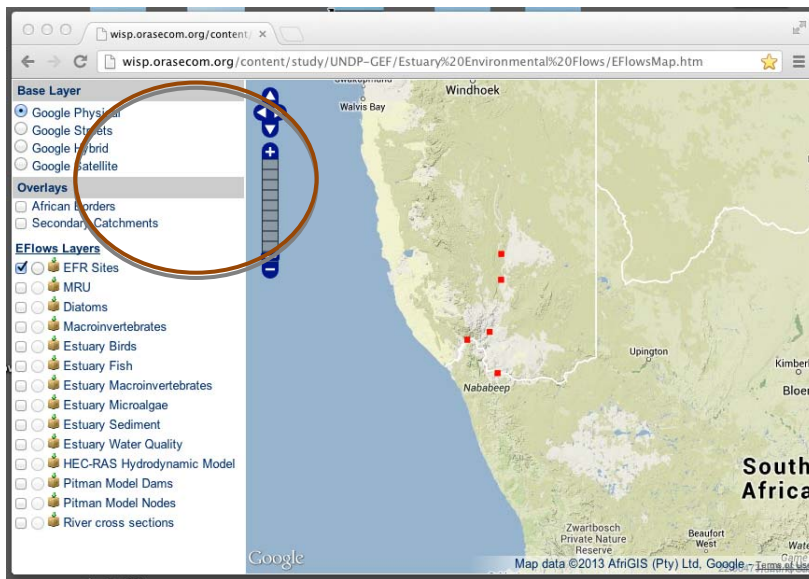
The interactive map has been created with the purpose of presenting geographical location of data sets generated in the Project. The map uses WIS GeoServer GIS functionality.

The map is available at: [http://wis.orasecom.org/content/study/UNDP-GEF/Estuary Environmental Flows/EFlowsMap.htm](http://wis.orasecom.org/content/study/UNDP-GEF/Estuary%20Environmental%20Flows/EFlowsMap.htm)

The Map window contains a panel displaying the map, and a control panel (marked in the figure below) allowing for selecting which layers are to be displayed in the map.

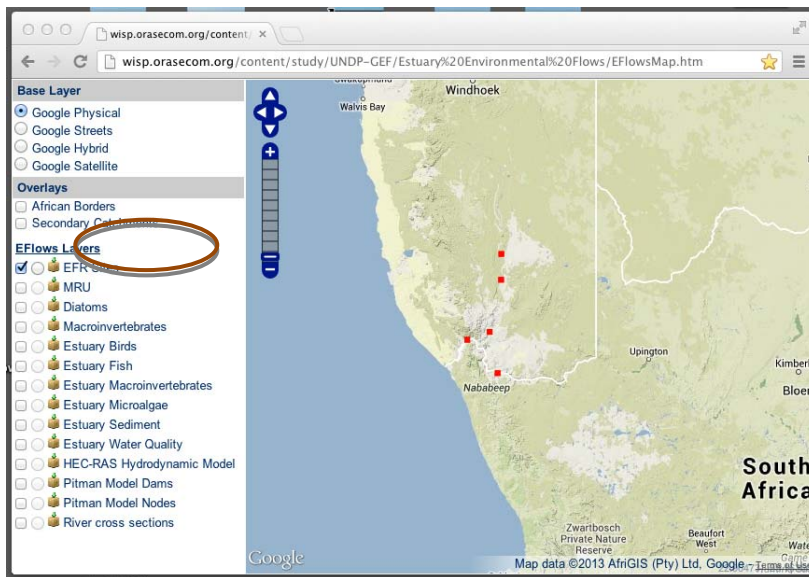


The control panel contains a number of generic layers, such as Google physical layer, major rivers of the Orange basin, national boundaries etc.



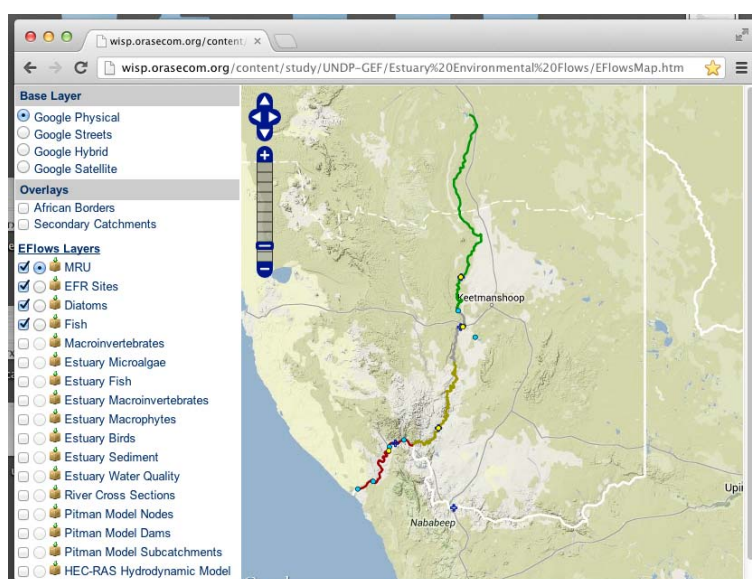
The control panel also lists all Project layers, which are shown under the heading 'EFlows layers'.

For each layer, next to its name, there is a tick-box, a radio-button and a symbol of a parcel.



4.1 Tick box

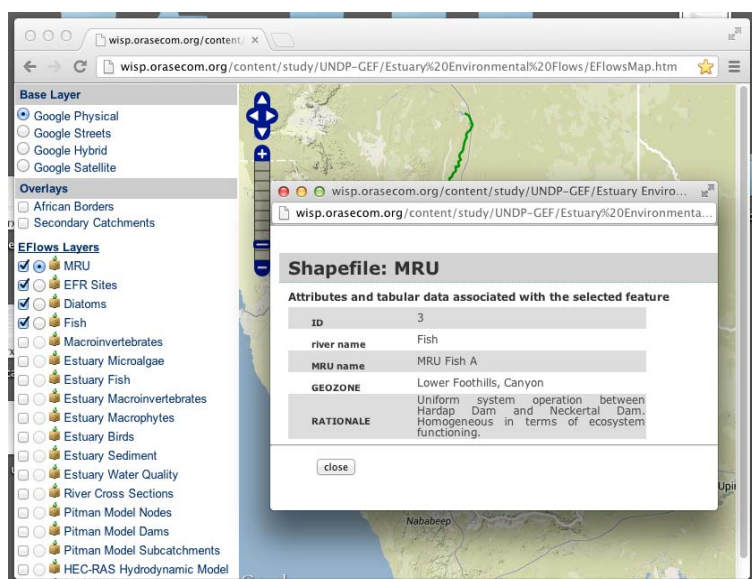
Clicking on the tick-box causes the selected layer to be displayed in/removed from the map window. More than one layer's tick box can be selected, and this will result in multiple GIS data layers to be displayed in the map window.



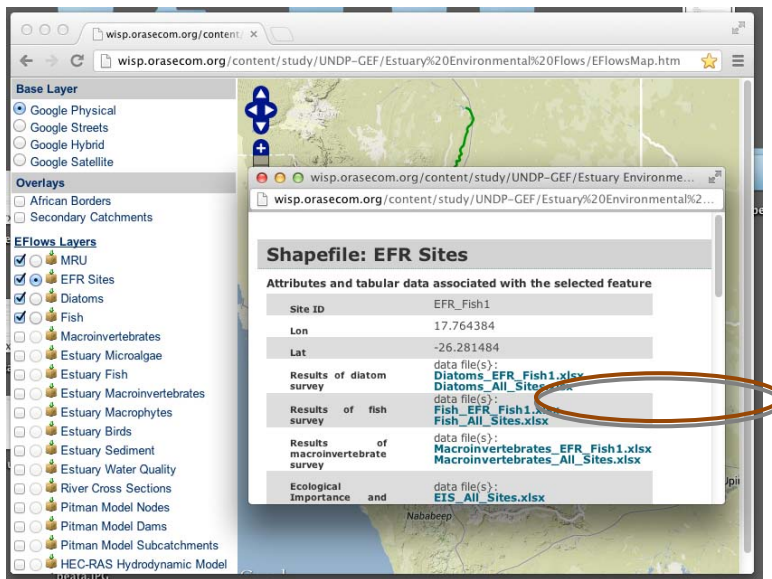
4.2 Radio-button

The radio-button enables querying features (individual geographical entities) shown in the map. When the radio-button is on, clicking on a feature shown in the map displays a new window that contains data for the selected feature.

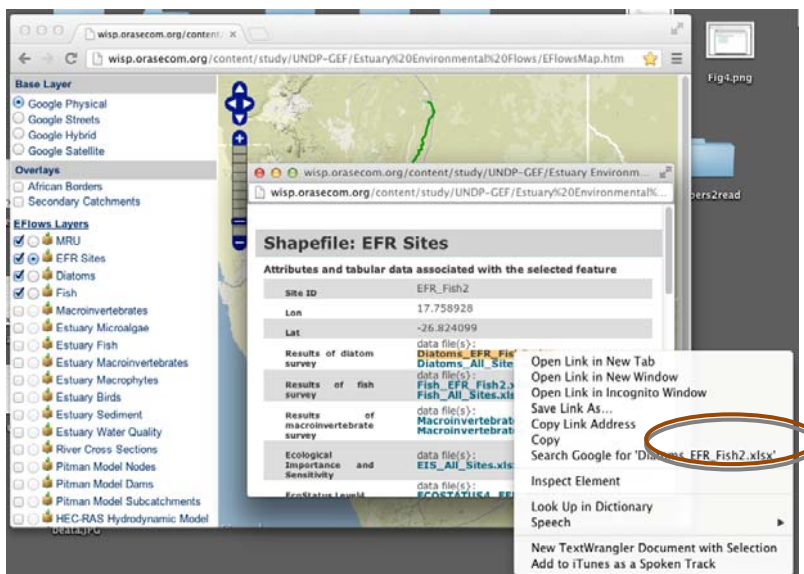
If there are no external tabular attribute data associated with the selected feature, the new window will contain just the basic info about the feature: name, ID, type, as in the figure below.



If there exist external attribute data or figures or photos associated with the selected feature, the new window will contain links to the relevant files, as in the figure below.

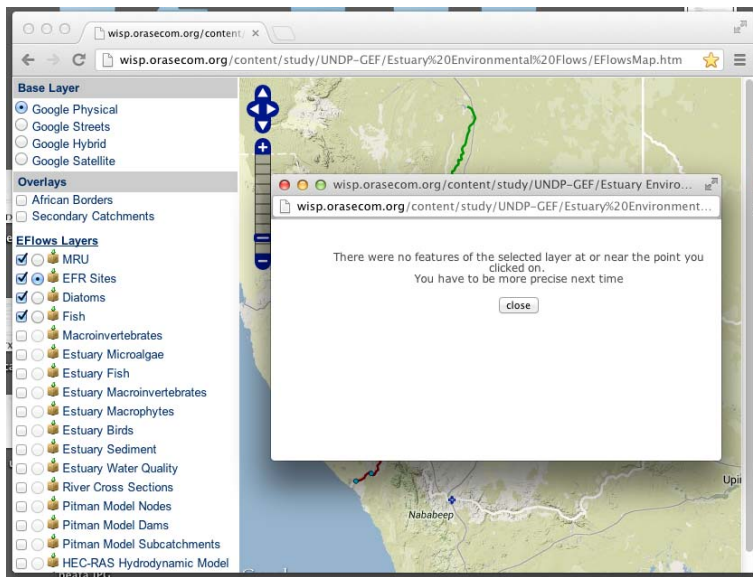


To download a file, user has to right-mouse click on the links in that window and select 'Save file as...' from the contextual menu.



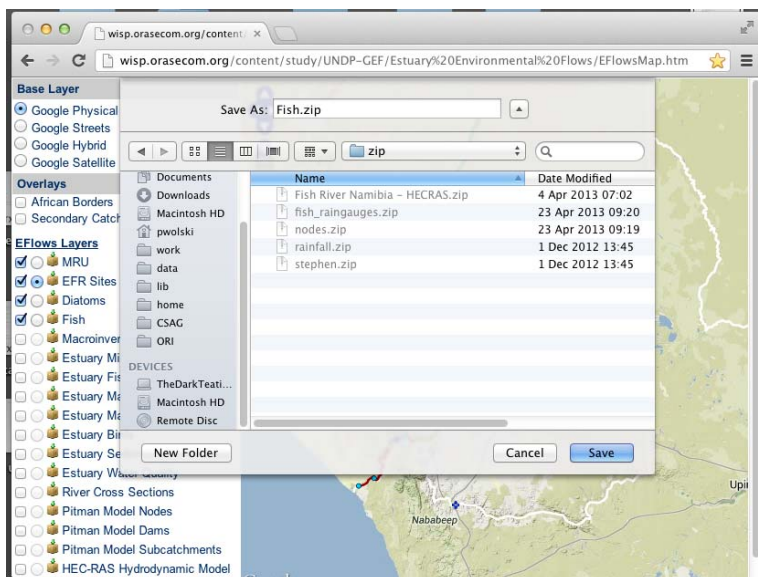
Only one radio button can be on at a time, or in other words, only one layer can be selected for displaying description of its elements.

Clicking on map features/objects when none of the radio buttons is on will have no effect at all. However, clicking of features/objects from a layer that is not selected at the time, or clicking on locations where there are no features (apart from the background map) will cause an error window to appear as in the figure below:



4.3 The parcel symbol

Clicking on the parcel symbol next to the layers' name will initiate downloading of files storing that layer.



The GIS data are downloaded as a single zipped file. That file contains six files which store the layer in ArcView shapefile format. The shapefiles can be opened and further manipulated in any off-line GIS software.

5. Using the geographical and attribute data independently of WIS

Each of the shapefiles storing geographical features in the e-flows project's database contains an attribute table for the layer. The convention adopted for the e-flows project's database is such that complex attribute data are not stored in the shapefiles attribute tables, but in external ASCII or MS Excel files. Shapefile attribute tables contain references to these external files. While web interface and WIS map, as described above, facilitate access to these external attribute files, these external files can also be accessed directly and manipulated off-line.

5.1 Structure of shapefile attribute tables

Shapefile internal attribute table stores information for individual geographical features in a number of (user-defined) columns. EFR database stores data in columns with names formulated according to a certain pattern.

In situations where shapefile attribute table stores data directly, column name represents the code for the variable stored in that column.

However, if the shapefile attribute table stores reference to an external attribute file, column name represents code for the variable, and data type stored in the external files.

For example, a column name 'vegrai_dat' represents a code for variable stored in that column ('vegrai') and data type for that variable ('dat').

There are three possible data types:

- 'dat' – representing tabular attribute data;
- 'fig' – represents a figure or a graph;
- 'pic' represents a photo.

5.2 Metadata file

The meaning of variable codes is captured in the metadata file, which is accessible from the Project's web page under the Metadata section. This file is located in [http://wis.orasecom.org/content/study/UNDP-GEF/Estuary Environmental Flows/Metadata/Shapefiles_metadata/shapefiles_db_columns.csv](http://wis.orasecom.org/content/study/UNDP-GEF/Estuary%20Environmental%20Flows/Metadata/Shapefiles_metadata/shapefiles_db_columns.csv)

The metadata file is a comma-separated value (csv) file, which can be viewed in MS Excel or any text editor.

The metadata file contains the following information:

- Variable's code;
- Variable's full name;
- Thematic category;
- Dataset name;

In case when references to external files are stored in the internal shapefile attribute table, the table stores file name only. The location of the external file on the WIS system can be obtained as follows:

http://wis.orasecom.org/content/study/UNDP-GEF/Estuary Environmental Flows/thematic_category/dataset_name/file_name.ext

where:

- Thematic_category represents thematic category of the variable obtained from the metadata file;
- 'dataset_name' represents name of the dataset for the variable, obtained from the metadata file;
- 'file_name.ext' represents name of the external attribute file stored in the shapefile attribute table.

Shapefile attribute table may contain reference to more than one external attribute file for a single geographical feature. In such a case, there are more than one entries in the shapefile attribute table, separated by ';' symbol.