FLOOD SECURITY STRATEGY
– CASE STUDIES FROM GDANSK REGION

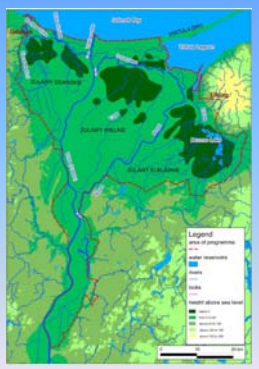
Andrzej Lewandowski – DHI Poland
Piotr Kowalski – Regional Water Management Board of Gdansk
Wojciech Szpakowski – Gdansk Waters

Content of presentation

1. **Introduction**
2. **Flood protection of Gdansk**
3. **Programme for Zulawy region – complex flood protection**
4. **Redevelopment of the Vistula estuary**
5. **Elblag case study**
6. **Conclusions**

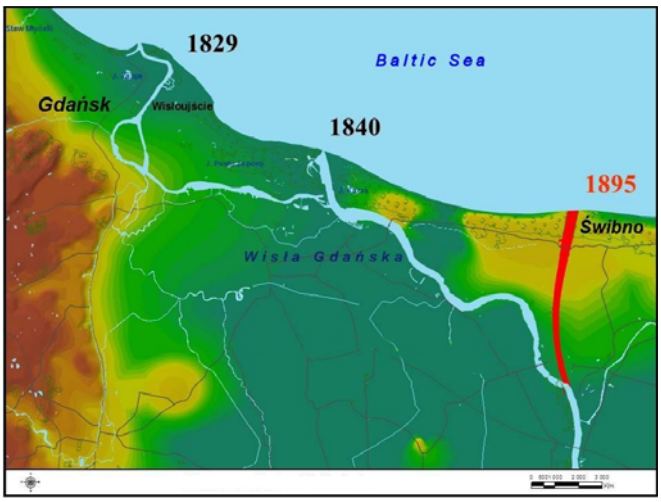
Characteristic of Zulawy area

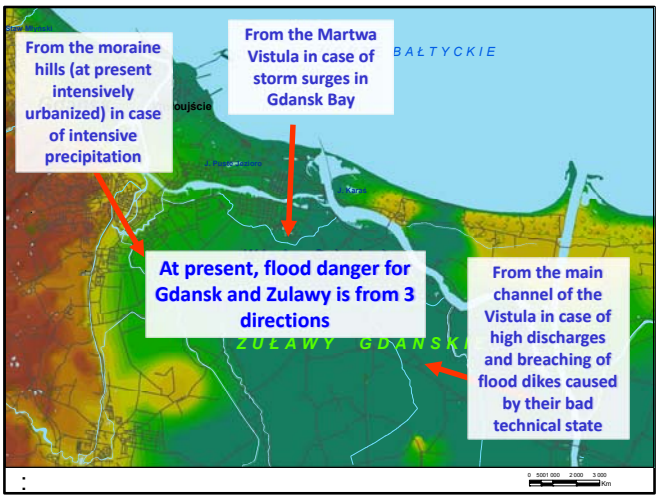
- covers about 2 150 km^2, including 454 km^2 of depression area
- about 250 000 inhabitants
- rich in biodiversity and protected areas
- mainly rural usage
- large-industrial developing is located in Gdansk, Elblag, Tczew
- important infrastructure - railway and roads, pipeline, electrical power facilities

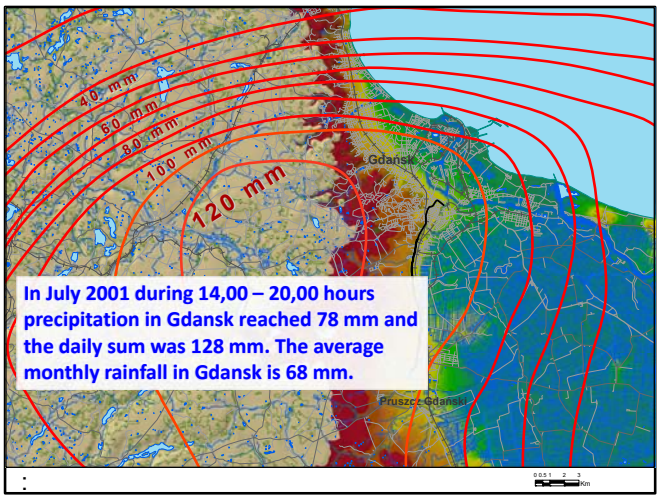


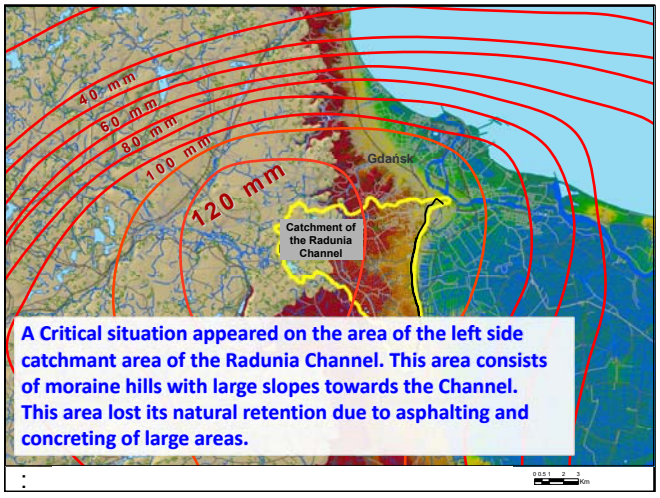
The effective flood protection

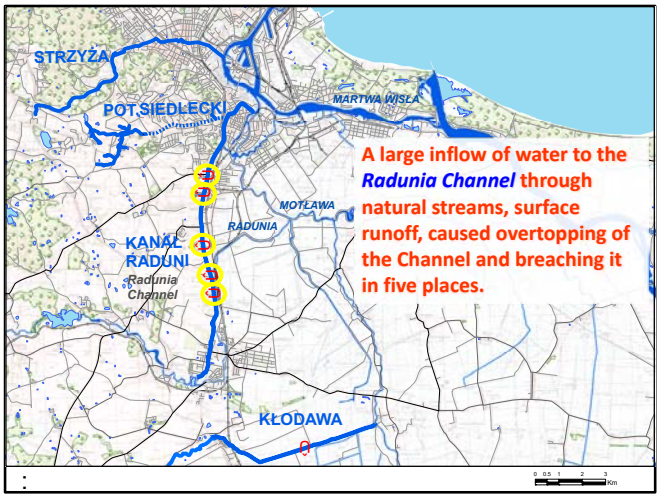
- protection of the population against the flood threat
- functioning of an intensive large-industrial development located in the region as well as the functioning of important technical infrastructure corridors (e.g. road, railway, pipeline, electrical power engineering)
- preservation of the most valuable nature resources, including in particular the fertile soils of Zulawy region
- better security of national heritage objects, including the most valuable complexes of historical monuments (in particular the castle of the Teutonic Knights in Malbork, Gdansk within the Medieval walls, Wisloujscie Fortress, Medieval churches of Zulawy etc.)

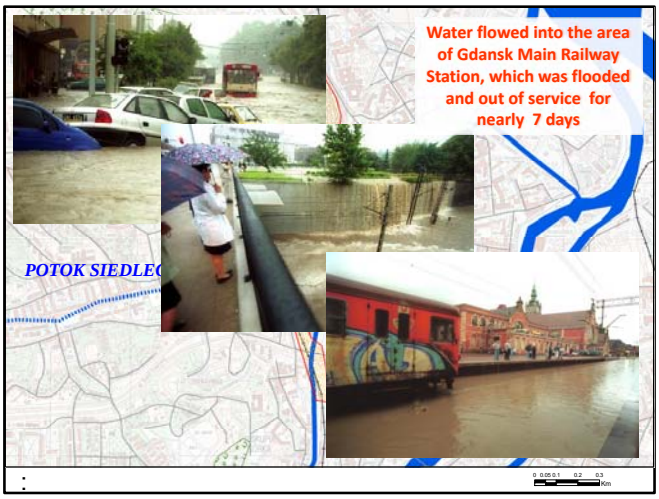


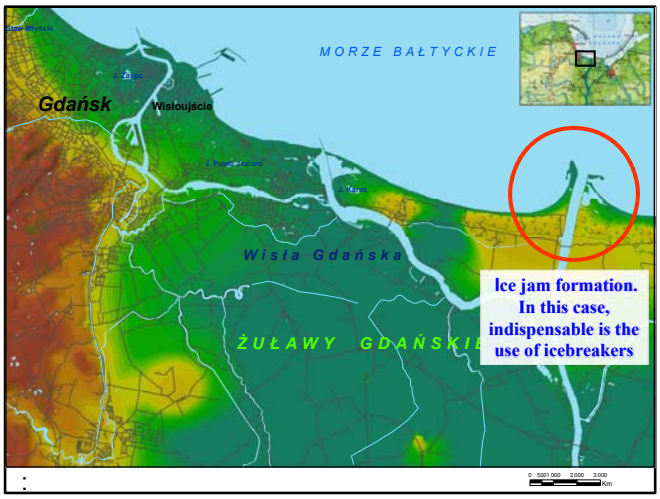

From the moraine hills (at present intensively urbanized) in case of intensive precipitation
From the Martwa Vistula in case of storm surges in Gdansk Bay
BAŁTYCKIE
At present, flood danger for Gdansk and Zulawy is from 3 directions
From the main channel of the Vistula in case of high discharges and breaching of flood dikes caused by their bad technical state
ŻUŁAWY GDAŃSKI


40 mm
60 mm
80 mm
100 mm
120 mm
Gdansk
In July 2001 during 14,00 – 20,00 hours precipitation in Gdansk reached 78 mm and the daily sum was 128 mm. The average monthly rainfall in Gdansk is 68 mm.
Pruszcz Gdański


40 mm
60 mm
80 mm
100 mm
120 mm
Gdańsk
Catchment of the Radunia Channel
A Critical situation appeared on the area of the left side catchmant area of the Radunia Channel. This area consists of moraine hills with large slopes towards the Channel. This area lost its natural retention due to asphalting and concreting of large areas.


STRZYŻA
POT.SIEDLECKI
MARTWA WISŁA
MOTŁAWA
RADUNIA
KANAŁ RADUNI
Radunia Channel
KŁODAWA
A large inflow of water to the Radunia Channel through natural streams, surface runoff, caused overtopping of the Channel and breaching it in five places.

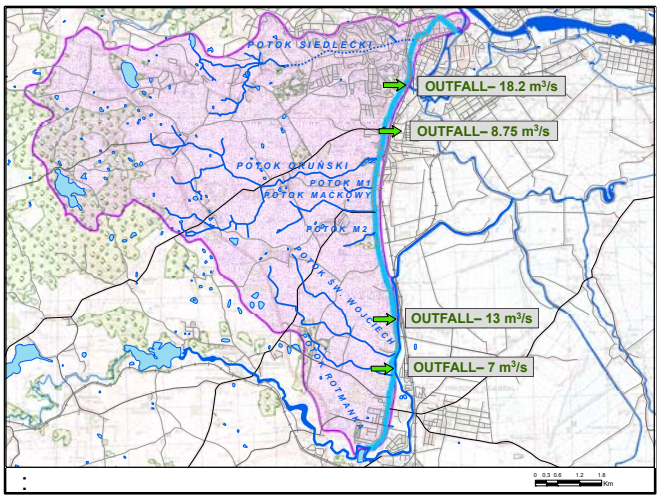

Water flowed into the area of Gdansk Main Railway Station, which was flooded and out of service for nearly 7 days
POTOK SIEDLEC

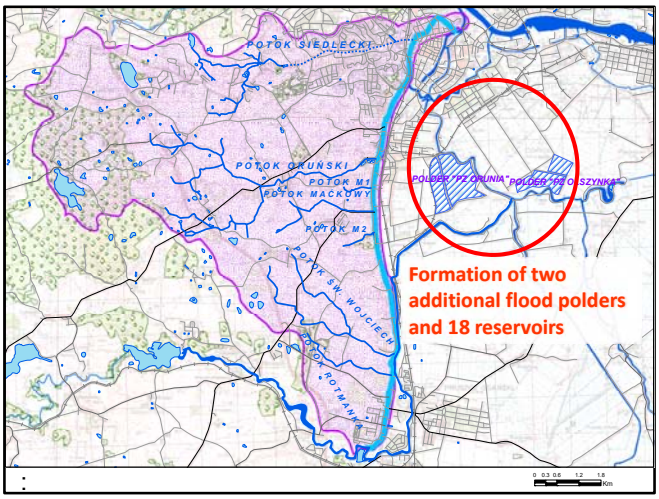

MORZE BAŁTYCKIE
Gdańsk
Wisloujście
Wisła Gdańska
ŻUŁAWY GDAŃSKI
Ice jam formation. In this case, indispensable is the use of icebreakers

To avoid such situation in the future an action divided in two stages has been taken

At first the consecutive studied started which included:

- field measurements of all streams and channels of Gdansk Water Node (GWN) consisting of cross sections and longitudinal profiles
- hydrologic analysis of GWN
- formulation of numerical model for unsteady flow (Mike 11)
- simulations of various proposals aiming to flood elimination (Mike 11).





Isohyets of rainfall in Gdansk (August 1, 2018).

Currently, rainwater management system consist of 51 reservoirs (including 18th already mentioned) located in Gdansk catchment. This artificial retention is closely connected with a number of natural streams. More than 10 reservoirs are constructed as parts of a rainwater canalization system. The main goal of such conception is to controlling the outflow from the catchment. The total retention volume of reservoirs exceeds 700,000 cubic meters.

An important part of Gdansk rainwater management system is a municipal hydrological monitoring system. The system consists of 25 rain gauges (mostly the weight instruments) and 75 water level measurement stations. Rain collectors are located in city districts which allows for the accurate registration of local rain, which for example occurred in 2018.

The data are also collected for the calibration of numerical hydrodynamic models which are currently being set up for the successive catchments of Gdansk.

The idea is to start numerical modelling with the most important catchments in order to create different scenarios in view of heavy rain.

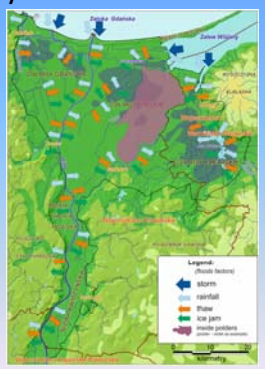
Within company there are 13 mobile groups scattered over the Gdansk catchment which continuously supervise the drainage system consisting of reservoirs polders, melioration channels.

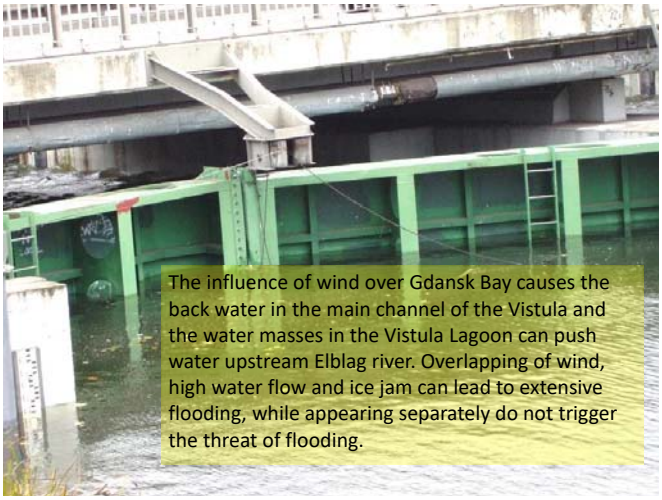
Moreover based on weather forecast and data from measurements stations the groups and may quickly react by steering of reservoirs outflow.

Zulawy - Factory of floods

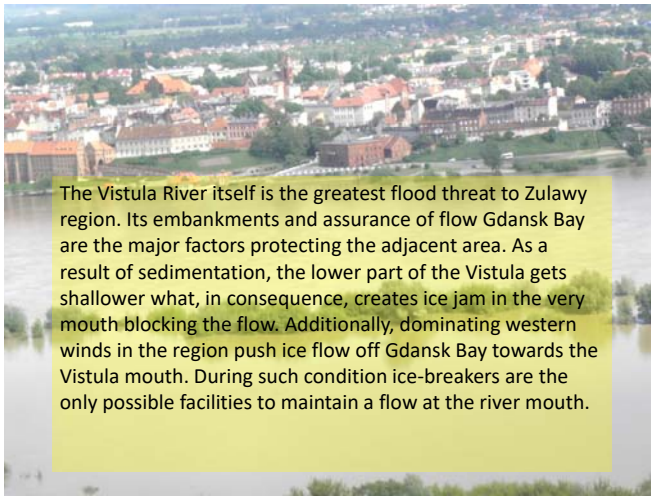
A threat of flood appearance in Zulawy region area can come from few directions and can be a result of diverse factors:

- storm as a result of wind over Vistula Lagoon
- breaching of Vistula embankments caused by a high flow or ice jam in the very mouth
- rain, thaw inside polder area – caused by a downpour and/or thawing in the polder areas while the irrigation can become insufficient
- long-term power cuts of the drainage pump stations

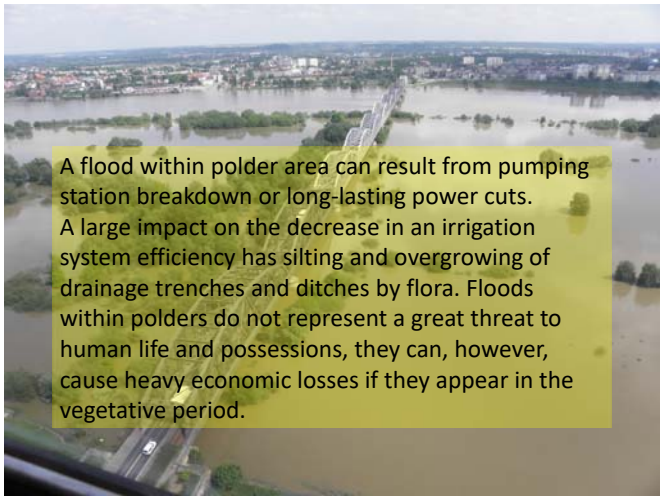




The influence of wind over Gdansk Bay causes the back water in the main channel of the Vistula and the water masses in the Vistula Lagoon can push water upstream Elblag river. Overlapping of wind, high water flow and ice jam can lead to extensive flooding, while appearing separately do not trigger the threat of flooding.



The Vistula River itself is the greatest flood threat to Zulawy region. Its embankments and assurance of flow Gdansk Bay are the major factors protecting the adjacent area. As a result of sedimentation, the lower part of the Vistula gets shallower what, in consequence, creates ice jam in the very mouth blocking the flow. Additionally, dominating western winds in the region push ice flow off Gdansk Bay towards the Vistula mouth. During such condition ice-breakers are the only possible facilities to maintain a flow at the river mouth.



A flood within polder area can result from pumping station breakdown or long-lasting power cuts. A large impact on the decrease in an irrigation system efficiency has silting and overgrowing of drainage trenches and ditches by flora. Floods within polders do not represent a great threat to human life and possessions, they can, however, cause heavy economic losses if they appear in the vegetative period.

"Programme for Zulawy to 2030 – complex flood protection"

The main goals of the Programme concerned:

- improvement of flood threat identification and prevention using the best available techniques and the best practicable means according to the EU directives and national policy,
- improvement in the organizational structures of the flood control and the flood risk management on the regional and local level,
- reconstruction and construction of water engineering facilities including "natural" flood prevention methods,

The Programme itself is divided in two stages: stage I till 2015, following stages after 2015 till 2030.

"Programme for Zulawy to 2030 – complex flood protection"

Stage I of the Programme

Stage I of the Programme focused on repairs, reconstructions and modernization of existing facilities including pumping stations, levees and embankments of water courses and canals.

As results the following tasks have been completed.

- total of 65,6 kilometres of reconstructed riverbeds (rivers: Motlawa, Waska, Dzierzgon, Babica),
- construction of 13 hydraulic facilities (11 spurs on the Vistula river, and 2 breakwaters in the mouth of the Vistula),
- reconstruction of 75.6 km of levees (on the Vistula river and Tuga river, embankments of the Elblag river),
- reconstruction of 34 pumping stations,
- reconstruction of 10 km of Radunia channel
- construction of a 1km steel wall to strengthen the bank of the Elblag river,
- construction of the pump reservoir with a capacity of 2,225 m3.
- 19th hydro-meteo monitoring stations.

II stage of the Programme for Zulawy 2030

Tasks proposed for Stage II of the Programme have been chosen basing on multicriterial analysis as well as already mentioned flood hazard and flood risk maps.

Priority will be given to tasks aimed at the threat of the largest scale, mainly regional and sub-regional in order to reduce flood losses primarily in the city of Gdansk, highly industrialized lands and historic sites.

A group of lower-priority tasks will concern protection against flooding of rural and agricultural areas, mainly in the polders.

A total of 49 tasks was qualified to the Programme, of which 14 have been given high priority, and 35 medium priority. In addition, there was a reserve list of 13 tasks.

ELONGATION OF BREAKWATERS AT VISTULA MOUTH

A number of breakwater length at various flow conditions have been simulated to find the optimum situation from engineering and ecological point of view (the mouth region is subjected to Birds and Settlements Directives).

As the results of the above studies the following recommendations have been formulated:

- Elongation of both breakwaters the at the river mouth is the only effective method of prevention against appearance of ice jams

Among the analysed options the optimum solution will be obtained by the elongation of western and eastern breakwaters by 550m and 600m respectively.

Up till now western and eastern breakwaters have been renovated with the elongation of eastern breakwaters by 200m.

Eastern breakwaters – before renovation

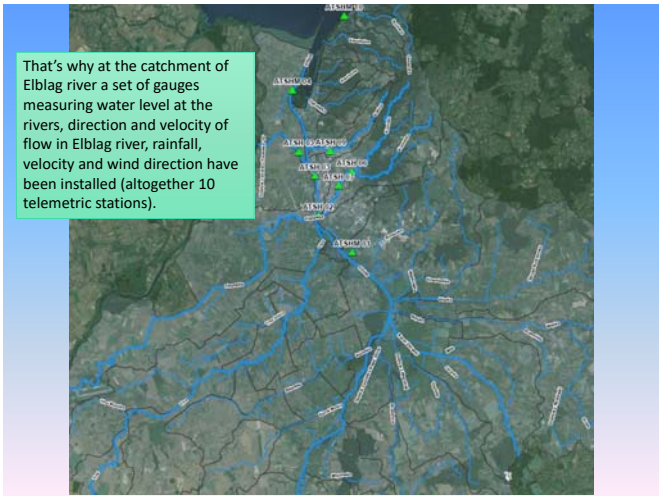
Western breakwaters – before renovation

Eastern breakwaters – present state

Western breakwaters – present state

Eastern breakwaters – new preabricated elements

Due to specific topography ranging from wide flat polders and floodplains with elevation below sea level to hilly landscape, city of Elblag is affected by different kind of floods. Flash floods caused by heavy rainfall occur frequently as well as long lasting floods caused by snow melting.



That's why at the catchment of Elblag river a set of gauges measuring water level at the rivers, direction and velocity of flow in Elblag river, rainfall, velocity and wind direction have been installed (altogether 10 telemetric stations).

So based on hydrological and meteorological data and measurements data it was possible to set up a mathematical model of the catchment (Mike 11) taking into consideration not only the rivers of the catchment but also the net of sewers.

The calibrated model made possible to determine the flood hazard maps as well as to run different scenarios in order to know what may happen in view of extreme phenomenon.

Conclusions

The system of flood protection of Zulawy region is still under development.

Right now the second stage of Programme for Zulawy region is realized taking into account the effects gained during the first stage.

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Conclusions

As to Gdansk city the rainwater management system consisting of reservoirs, polders, outfalls make possible to control outflow from the catchment.

The municipal hydrological monitoring system allows to collect data in order to set up and calibrate numerical hydrodynamic model of the catchment to simulate different scenarios.

Weather forecast, data from monitoring and simulated scenarios enable to quick reaction by steering of reservoirs outflow.