Modern information technologies for inventory of objects of ameliorative network of St. Petersburg

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Abstract. A functional diagram of the inventory of land reclamation networks in St. Petersburg is proposed. Its main element is geo-information systems of visualization of geo-data, filled in on the basis of cartographic materials, topographic tablets, the results of satellite imagery and aerial photography, the results of field surveys of open and closed land reclamation systems. The advantage of the proposed approach is to reduce the laboriousness of work on the inventory of ameliorative network, the definition of its functional purpose and technical condition. The results of the inventory are presented in a single geo-information complex, which allows online access to any cartographic and attribute data.

Up to the 90s of the 20th century, a well-developed network of land-reclamation canals operated in the territory of St. Petersburg was created to drain agricultural land of 15 state farms in Leningrad. The main agricultural lands were located in Vyborgsky, Pushkinsky and Moskovsky districts of St. Petersburg [1].

The drainage system of the Leningrad was represented by a protective network protecting the territory from the inflow of surface and groundwater from adjacent lands; a regulatory network designed to regulate the water regime of soils by collecting excess water inside the drained area; conductive network serving to receive water from the regulatory and protective networks and drain it into the water intake.

Since the 90s of the 20th century, the area of farmland has steadily declined, and massive construction has taken place in the liberated territories. At the same time, the reclamation canals either were liquidated, or came to an unsatisfactory condition, or continued to perform their functions, but already to drain residential and industrial areas [2-4].

The loss of channel performance was caused by numerous reasons, the main of which are: erosion of the channel at high speeds of currents; sedimentation of the channel most likely for channels with small slopes; the overgrowing of the channel of various weeds and marsh vegetation, shrubs and trees, reducing the depth of the channels; the collapse of slopes and their destruction by surface runoff, groundwater and seepage forces [5].

The above reasons have led to the efficiency loss of a significant ameliorative network part, and as a result of the partial loss of efficiency and flooding of large areas. To ensure the efficiency of the
ameliorative network, it is necessary to carry out repair and operational measures, including: operational measures, current, capital and emergency repairs.

The development and implementation of repair activities at the reclamation network sites was often hampered by the loss or change of ownership of these channels, the partial loss of documentation through the channels or the lack of funding. Therefore, the primary task is to determine the location and functional purpose of the melioration network facilities with an assessment of its technical condition.

An inventory of land reclamation systems only during field surveys makes this task highly costly, since the ameliorative drainage network of St. Petersburg was located on areas hundreds of thousands of hectares.

The authors proposed a comprehensive functional diagram of the inventory of the ameliorative network, tested at the facilities of the ameliorative network of St. Petersburg.

**Figure 1.** Functional diagram of the inventory of the ameliorative network objects of St. Petersburg.
According to the proposed scheme, at the first stage, the available cartographic material is collected. The primary information for the inventory are:

- Cartographic materials of the administration of St. Petersburg, containing the following main data layers: relief, driveways, amelioration channels, ring-road, water courses, functional zoning and water bodies.
- Topographic tablets on a scale of 1: 2000 in AutoCAD format in the projection Gauss_Kruger.
- Cartographic materials of organizations operating melioration systems.
- Satellite observations.

Cartographic materials and topographic tablets were connected to the GIS "Melioration" in the ESRI ArcGIS format. On the basis of the plates, the hydrographic network was derived in a separate layer. The hydrographic network layer contained all types of drainage facilities: ameliorative network, watercourses, watercourses, ditches. By comparing and analyzing the data of the hydrography layer and the layers: reservoirs, water courses and reclamation network, duplicate objects were removed from it.

The obtained topographic tablets and cartographic materials often did not reflect the actual situation, since most of them were created during the Soviet period. Open sources of space shooting Yandex and Google maps allow you to get quite relevant cartographic material, but they can be performed during the growing season, when the outlines of the channels are not visible due to vegetation. To obtain satellite images of the territory of St. Petersburg, the software product SASPlanet was used, allowing cutting cartographic materials without loss of quality, in the coordinate system from Google and Yandex open resources [6]. Using the functionality of ArcGIS, the images were tied to the coordinate system of the projection - the city, the projection Gauss_Kruger.

At the next stage, all the cartographic materials were brought to a single coordinate system and uploaded to the developed GIS "Melioration", created on the basis of the software product ArcGis. GIS "Melioration" allowed viewing any of the connected layers. According to the results of processing all the information received, 19090 melioration network facilities were mapped. Based on a comparison of satellite images with topographic tablets, the changes in the relief were revealed.

An example of the overlay of the layer of ameliorative channels on the satellite image is shown in figure 2. It can be seen from the picture that, in connection with construction works in this area, there are no land-improvement channels.

![Figure 2. Refining the boundaries of channels for space imagery.](image)
According to the results of the comparison of topographic tablets with the data from space imagery, the geometry of the ameliorative channels is adjusted.

When an inventory of ameliorative network is carried out over large areas, aerial photography of the territory becomes economically justified. Its main advantages are high resolution, the possibility of obtaining relevant cartographic materials, conducting surveys in the most significant periods of lack of vegetation, when the outlines of the channels are traced as closely as possible [7–8].

On the basis of the GIS “Melioration” the route of aerial photography was determined. The aerial photography route should cover the territories where intensive construction was carried out; there were complaints of flooding of the territories, territories not covered by actual cartographic material. After choosing the route for aerial photography, reconnaissance airborne bombings of the territory were carried out in order to clarify the location of melioration systems and determine the effectiveness of aerial photography. At the next stage, digital aerial photography itself was carried out and orthophotoplans were formed with the help of specialized software to prevent distortion of the territory.

Orthophotos are a high-quality survey of the earth's surface, tied to a coordinate system. Orthophotoplans were attached as data layers to the GIS-Land Reclamation system developed in ArcGis. The refinement of the boundaries of the ameliorative channels was carried out by superimposing the obtained layers of these ameliorative channels on the cartographic submarine, with subsequent analysis of the cartographic information. An example of updating the boundaries of melioration channels is shown in figure 3.

![Figure 3. Refinement of the boundaries of channels for aerial photography.](image)

For reclamation channels, the results of the aerial photography decoding were determined: the geometry of the channels, their length and width, the presence of vegetation in the channel and on its edges, places of significant garbage accumulation, and the modern functional purpose of the territory.

The use of space imagery, aerial photography in conjunction with topographic tablets, has significantly reduced the volume of field surveys of channels. However, it is impossible to completely eliminate field surveys, since satellite imagery and aerial photography often do not provide acceptable results in populated areas, since there are no conditions for direct visibility of the channels of the channels. In addition, aerial photography does not allow studying the state of the closed part of the ameliorative network, primarily the state of pipe crossings and closed collectors.

Therefore, at the final stage, field surveys were conducted during which an actual assessment was made of the use and condition of areas of land-improvement systems, assessment of the status and operability of the drainage network and facilities on the drainage network, assessment of the condition and operability of the conductive network and facilities on the conductive network, recording changes
in the structure of land use: definition of actual boundaries, changes in the type of use and ownership of territories.

All the results of field surveys were recorded in the GIS "Melioration". According to the results of the inventory, depending on the state of a particular channel, the necessary measures were developed: monitoring the state of the system, identifying local damage, painting the channel slopes, and cleaning channels from foreign objects; cleaning canals from scrub and sediment; cleaning and repair of pipe crossings; repair of the mouths of closed headers; debris removal; overhaul and emergency repair.

Developed by GIS "Land Reclamation" allowed: to unite scattered cartographic material into a single system; edit the location of the ameliorative network using topographic tablets, aerial and satellite images, enter the channel parameters in the attribute tables, calculate the catchment areas of the main canals.

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