Environmental Monitoring of Darial Hydropower Plant Construction and Operation

Botanical Component

The first phase of the monitoring of the botanical component of the Darial hydropower plant construction and operation was carried out on 18 August, 2015

Site 1. GPS coordinates 0471239/4725694, 1689 m above the sea level, the tunnel south portal areas (at the "Rock Feet"). The situation has not changed substantially. On the top of the portal, on the cliffs there grows *Juniperus depressa*. On the area adjacent to the portal, in the south-eastern slope there is just the initial stage of grassing. Out of pioneer plants there grow *Artemisia absinthium, Fumaria scheicheri,* Verbascum sp., Cirsium sp., *Salvia verticillata, Polygonum convolvulus, Sedum oppositifolium, Melandrium boissieri.*

Site 1. Areas of the southern portal of the tunnel

Site 1. *Artemisia absinthium*

Site 1. *Fumaria scheicheri*

Site 1. Verbascum sp.

Site 1. *Sedum oppositifolium*

Site 1. Cirsium sp.

Site 1. *Melandrium boissieri*

Site 1. *Polygonum convolvulus*

Site 1. *Salvia verticillata*

Site 2. GPS coordinates 0471193/4725653, 1693 m a.s.l., the portal surrounding areas. West exposure, slope -30-35^0. The slope below the newly laid road (which is made above the power conduit). No vegetation is seen yet in this area, so the pioneer plants are not growing. In the areas after the construction and in the natural (landslide) gravel flows there are remained sea buckthorns in kind of small isles, where goat willow *(Salix caprea)*, barberry *(Berberis vulgaris)*, dog rose *(Rosa canina)*, juniper *(Juniperus depressa, J. sabina)* interfere.

Site 2. Sea buckthorns represented in the natural (landslide) gravel flows in kind of small isles with interfered goat willow, barberry, dog rose, juniper

Site 2. Sea buckthorns represented in the natural (landslide) gravel flows in kind of small isles with interfered goat willow, barberry, dog rose, juniper

Site 2. Sea buckthorns represented in the natural (landslide) gravel flows in kind of small isles with interfered goat willow, barberry, dog rose, juniper

Site 3. GPS coordinates 0471229/4725553, 1696 m a.s.l. West exposure, slope -35^0. The pioneer phase of vegetation restoration on the rocky soil after construction of the power conduit, which is represented by the following plant species: *Bromopsis variegata, Artemisia absinthium, Trifolium ambiguum, Mentha longifolia, Poa pratensis,* Cirsium sp.

Site 3. The pioneer phase of vegetation restoration on the rocky soil after construction

Site 3. *Bromopsis variegata*

Site 3. *Trifolium ambiguum*

Site 3. *Trifolium ambiguum*

Site 4. GPS coordinates 0471236/4725456, 1698 m a.s.l. slope - 0^0. The area of the power conduit below the debris cone on the Kuro slope. The pioneer phase of vegetation restoration on the rocky soil after construction is represented by the following plant species:: *Artemisia absinthium,* Cirsium sp., *Senecio sosnowskyi*-kavkasiis endemi, *Nardus stricta, Polygogonum aviculare, Poa pratensis, Xeranthemum squarrosum, Tussilago farfara, Carduus onopordioides, Chamerion dodonaei.* Below the pipeline way on the newly filled soil restoration of vegetation has not begun.

Site 4. *Senecio sosnowskyi*-Caucasian endemic

Site 4. *Artemisia absinthium*

Site 4. *Nardus strictta*

Site 4. *Carduus onopordioides*

Site 4. *Chamerion dodonaei*

Site 4. *Polygogonum aviculare*

Site 4. *Nardus stricta*

Site 4. *Tussilago farfara*

Site 4. *Polygogonum aviculare*

Site 5. GPS coordinates 0471265/4725318, 1699 m a.s.l. West exposure, slope -15-20^0. The grass artificially seeded and grown up should be Poa sp. On the upper slope of the conduit way on the gravel soils after construction there are grown the pioneer species: *Leontodon hispidus, Moehringia trinervia, Trifolium ambiguum, Polygonum aviculare, Plantago saxatilis, Carduus onopordioides, Capsella bursa-pastoris.*

Site 5. Upper slope of conduit way

Site 5. Poa sp.

Site 5. *Leontodon hispidus*

Site 5. *Carduus onopordioides*

Site 5 . Poa sp.

Site 5. *Polygonum aviculare*

Site 5. *Capsella bursa-pastoris*

Site 6. GPS coordinates 0471244/4725217, 1701 m a.s.l. The section from the gas pipeline (where big stones are dumped). The same situation as in the previous site. The photos represent the upper and lower slopes of the conduit way.

Site 6. Upper and lower slopes of the conduit way

Site 6. Upper and lower slopes of the conduit way

Site 7. GPS coordinates 0471216/4725010, 1704 m a.s.l. The situation similar to the two previous sites. The natural meadow turfs occupy the slope which are located as the landslide isles. The plant species are: *Taraxacum officinale, Agrostis planifolia, Bromopsis variegata, Festuca pratensis* and other.

Site 7. Design corridor

Site 7. Natural meadow turfs occupying the slope as landslide isles

Site 7. *Taraxacum officinale, Agrostis planifolia, Bromopsis variegata, Festuca pratensis*

Site 8. GPS coordinates 0479162/4724777, 1707 m a.s.l.. West exposure, slope 15-20^0. The debris cone leveled by the machines above the road, the road below is the filled with stone-gravel soil. Pioneer plants have not been yet settled here. Artificial seeding is possible, though it is a landslide hazardous zone and development of mudflow and landslide processes is expected.

Site 8. Filled stone-gravel soil

Site 8. Filled stone-gravel soil

Site 9. GPS coordinates 0471173/4724502. 1703 m a.s.l. The sedimentation research is seen from this place. The situation at the conduit way is similar to the previous sites – the initial phase of vegetation restoration with pioneer plants. On both sides of the lower access road the natural vegetation is not damaged, where sea buckthorns and subalpine meadows are developed.

Site 9. The initial phase of vegetation restoration with pioneering plants.

Site 9. Natural vegetation on both sides of the road – sea buckthorns subalpine meadows

Site 10. GPS coordinates 0471022/4724128, 1708 m a.s.l. The area near the sedimentation research. The vegetation restoration has not started yet here. The photo represents the panorama of the whole conduit – from the sedimentation research to the portal.

Site 10. Total conduit from the sedimentation research to the portal

Site 10. Total conduit from the sedimentation research to the portal

Site 11. GPS coordinates 0469839/4730954, 1370 m a.s.l. North exposure, slope 90^0. The north portal of the Lars HPP conduit. Northern portal. The vegetation round the portal is destroyed. The vegetation of the adjacent cliff is preserved. .

Site 11. Petrophilous vegetation adjacent to the portal

Site 11. Petrophilous vegetation adjacent to the portal

The second phase of the monitoring of botanical components of the Darial hydropower plant construction and operation was carried out on October 17, 2015.

Site 1. From the portal of the pressure conduit (the Rock Feet site) on the post-construction stone-gravel soil there are yet the zero and initial phases of vegetation restoration. Here and there only pioneer plants are represented-*Artemisia absinthium*, Festuca sp., Verbascum sp., *Cirsium echinus*-rozetis stadiaze, *Hippophaë rhamnoides*.

Site 1. Areas of the upper portal of the pressure conduit tunnel

Site 1. Areas of the upper portal of the pressure conduit tunnel

Site 1. *Artemisia absinthium*

Site 1. *Hippophaë rhamnoides*

Site 1. Festuca sp.

Site 1. *Festuca varia*

Site 1. *Artemisia absinthium*

Site 2. To the south from the portal, on the west exposure slope where local plants were seeded last year, on the post-construction stone-gravel soil (the pressure conduit) there are represented pioneer plants: Festuca sp., *Cirsium echinus, Potentilla crantzii, Plantago saxatilis, Oxytropis cyanea, Carduus onopordioides, Polygonum aviculare*.

Site 2. Carduus onopordioides

Site 2. Verbascum sp.

Site 2. Sea-buckthorn on the area adjacent to the construction corridor

Site 2. Potentilla crantzii

Site 2. Where vegetation was not seeded, the pioneer plants do not grow. Out of naturally seeded *Plantago saxatilis* is on the first place. Here and there *Cirsium echinus* rosettes are present. .

Site 2. Pioneer plants resulted from artificial seeding

Site 2. *Plantago saxatilis*

Site 2. Pioneer plants resulted from artificial seeding

Site 2. *Plantago lanceolata*

Site 2. *Cirsium echinus* rosettes

Site 2. Pioneer plants resulted from artificial seeding

Site 3. In this section the sheep grazing is a hindering factor. The sheep paths and grazed pioneer pants are seen on the slopes.

Site 3. Sheep grazing in the designed corridor

Site 3. Pioneer plants resulted from the artificial seeding

Site 3. Designed area

Site 3. Pioneer plants resulted from the artificial seeding

Site 3. Polygonum aviculare

Site 3. Plantago saxatilis

Site 4. Further south, in the mudflow-erosion gully area (below the large stone), there is growing no pioneer plant because not long ago this area was still under construction (soil

grading) – here we see a stable stone-gravel soil (sterile artificial debris). In the future here the vegetation restoration processes is expected by natural and artificial way.

Site 4. Sterile artificial debris

Site 5. Further south, at the sedimentation research, on the newly leveled areas the vegetation restoration has not been started yet – no single-pioneer species is found. On the areas survived the construction („isles") we can see the growing *Festuca varia, Pyrethrum fruticulosum, Carduus onopordioides*.

Site 5. Sea buckthorn on the area adjacent to the construction site

Site 5. *Carduus onopordioides*

Site 5. *Pyrethrum fruticulosum*

Site 5. *Festuca varia*

Site 5. *Carduus onopordioides*

Site 5. Designed corridor

Site 5. Erosive ravines

Site 5. Old landslide cone