NATURE AND LANDSCAPE MANAGEMENT STANDARDS

WATER IN LANDSCAPE	CONSTRUCTION AND RECONSTRUCTION OF SMALL WATER RESERVOIRS USING A NATURE-FRIENDLY APPROACH	SPPK B02 007: 2022
SERIES B		

Výstavba a rekonstrukce malých vodních nádrží přírodě blízkým způsobem
Bau und Anpassung von Kleinwasserspeichern an naturnahen Stand

This standard contains definitions of technical and work procedures for construction and reconstruction of small water reservoirs (SWR) using a nature-friendly approach.

Quoted and recommended references:
Act no. 17/1992 Coll. on the Environment, as amended
Act no. 114/1992 Coll. on Nature and Landscape Protection, as amended
Act no. 254/2001 Coll. on Waters and on amendment of certain acts (Waters Act), as amended
Act no. 99/2004 Coll. on Pisciculture, Exercise of Fishing Rights, Fishing Patrol, Protection of Marine Fisheries and on amendment of certain acts (Fishery Act), as amended
Act no. 183/2006 Coll. on Spatial Planning and Building Rules (Building Act), as amended
Act no. 541/2020 Coll. on Waste, as amended

Government Regulation no. 318/2013 Coll., on the National List of Sites of Community Importance, as amended
MoE Water Protection Department Methodological Instruction on Minimum Residual Flow Rates in Watercourses (MoE Newsletter, year 1998, vol. 5)
MoA Methodological Instruction no. 1/2010 on Technical and Safety Supervision over Hydraulic Structures, ref. no. 37380/2010-15000
Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for Community action in the field of water policy

Decree no. 395/1992 Coll., executing some provisions of Czech National Council Act no. 114/1992 Coll. on Nature and Landscape Protection, as amended.
Decree no. 414/2013 Coll. on Water Management Records, as amended
Decree no. 590/2002 Coll., on Technical Requirements for Hydraulic Structures, as amended
Decree no. 197/2004 Coll., executing Act no. 99/2004 Coll. on Pisciculture, Exercise of Fishing Rights, Fishing Patrol, Protection of Marine Fisheries and on amendment of certain acts (Fishery Act), as amended
Decree no. 189/2013 Coll. on Protection of Woody Plants and Permission of Their Cutting, as amended
Decree no. 166/2005 Coll., executing certain provisions of Act no. 114/1992 Coll. on Nature and Landscape Protection, as amended, in connection with establishment of Natura 2000, as amended
Decree no. 216/2011 Coll. on Requisites for Handling Rules and Operating Rules of Hydraulic Structures, as amended
Decree no. 273/2021 Coll. on Waste Management Details, as amended
Decree no. 257/2009 Coll. on Use of Sediments on Agricultural Soil

ČSN 75 1400 Hydrological data of surface water
ČSN 75 2405 Water management analysis of reservoirs
ČSN 75 2410 Small water reservoirs
ČSN 75 2935 Assessment of hydraulic structure safety during floods
TNV 75 2102 Brook modification
TNV 75 2103 River modification
TNV 75 2910 Handling rules for hydraulic structures on watercourses
TNV 75 2920 Operating rules for hydrotechnical hydraulic structures
TNV 75 2401 Water reservoirs and weirs
TNV 75 2321 Making migration barriers passable using fish ladders

TNV 75 2322 Devices for migration of fish and other aquatic animals across obstacles in small watercourses
Vrána K., Beran J.: Rybníky a účelové nádrže, vydavatelství ČVUT, Praha 2013
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Documentation for the standard development is available in the NCA CR library.

Standard approved on ....

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1 Standard purpose and contents

The nature-friendly SWR standard defines principles for designing and constructing new SWR and reconstruction of existing SWR. The objective is to set basic parameters for preparatory, permitting and implementation processes and necessary inspection so that implemented solutions are ecological, efficient and functional.

The standard quotes essential information from technical standards dealing with the issues at hand, contains fundamental information for designing small water reservoirs from the point of view of nature-friendly solutions. In addition, the standard specifies information contained in several technical standards, decrees and other material. Where the present standard specifies information slightly different from technical standards, it concerns increasing safety of dams and functional structures of SWR.

Small water reservoirs are water bodies that perform or may perform some positive functions in nature and landscape, particularly ecological stabilization functions. The objective of SWR construction must always be a positive impact on the ecological status of the area.

The standard specifies minimum requirements that the designer should respect in the project design. Since every site has a different character, it is necessary for the designer to consult the plan with a regional office of the NCA CR as part of the project design. Differing design methods are permissible in some cases, but have to be properly justified.

Legal and technical framework

A small water reservoir is a hydraulic structure[1] under **Act no. 254/2001 Coll. on Waters** as amended (hereinafter, the Waters Act) and a structure[2] pursuant to **Act no. 183/2006 Coll. on Spatial Planning and Building Rules** (Building Act), as amended (hereinafter, Building Act).

In the case of reconstruction or changes to structures, the Building Act defines changes to a completed structure or maintenance works. Changes to a completed structure[3] comprise height extensions, side extensions and structural modifications that retain the outer footprint and elevation of the structure. Structural maintenance[4] refers to works that secure good structural condition so that the structure does not deteriorate and its usability is extended as much as possible.
When building a new SWR (i.e., executing a new construction) or modifying or maintaining it, the permitting regime under the Building Act that the project falls under should always be assessed.

From the point of view of **Act no. 114/1992 Coll. on Nature and Landscape Protection**, as amended (hereinafter, NLPA), a small water reservoir enjoys protection as a prominent landscape feature (PLF).[5] A PLF is an ecologically, geomorphologically or aesthetically valuable landscape component that constitutes its typical appearance or contributes to maintaining its stability. PLF legally include forests, peat bogs, watercourses, <u>fishponds</u> (SWR fall under this category of PLF)[6], lakes and floodplains, as well as any landscape components registered as PLF by a nature protection authority. PLF are legally protected from damage and destruction. They are only utilized in ways that do not disrupt their restoration and endanger or weaken their stabilization function. Interventions that might lead

[1] See Section 55, Para. 1, item (a) of Act no. 254/2001 Coll. on Waters, as amended.

[2] See Section 2, Para. 3 of the Building Act: *"A structure refers to any building works that are made using construction or assembly techniques, regardless of their structural or technical execution, construction products, materials or structures used, purpose of use or duration."*

3 See Section 2, Para. 5 of Building Act.

4 See Section 3, Para. 4 of Building Act.

[5] See Section 3, Para. 1, item (b) of the NLPA.

[6] In addition, a fishpond is defined in Section 2, item (c) of the Waters Act as a *hydraulic structure, being a water reservoir intended primarily for pisciculture, in which the water level can be controlled, including the ability to drain it and catch the fish; a fishpond comprises a dam, a reservoir and other technical devices.* Beyond this legal definition focused on production qualities of fishponds, fishponds also include near-natural biological (stabilization) ponds, reservoirs with predominantly recreational functions, etc.

to damage or destruction of a PLF or endangering or weakening its ecological stabilization function (e.g., affecting a watercourse or floodplain when constructing a SWR) require prior consent of a nature protection authority.[7]

Construction or reconstruction of SWR may also affect the landscape character[8] of the site (e.g., if the implementation is connected with extensive cutting of trees and shrubs, etc.). Activities that might reduce or alter (primarily negatively) the landscape character require approval of a nature protection authority.

Management of the vegetation accompanying SWR has to comply with general protection of trees and shrubs under Section 7 of NLPA.

Construction and reconstruction of SWR in specially protected territories (SPT) may also contravene basic SPT protection requirements (e.g., ban on locating and permitting new structures or ban on management using intensive techniques). In such cases, an exemption under Section 43 of NLPA has to be approved by an applicable nature protection authority (NPA). Besides, construction and reconstruction of SWR may be an activity bound to prior consent of an NPA as per the establishing regulations of the SPT. At the same time, the management plan of the SPT or set of recommended measures (for Sites of Community Interest) has to be followed.

If specially protected plant or animal species defined by Decree no. 395/1992 Coll. are present on the site, any planned activity that might lead to violation of the basic requirements for their protection requires a prior exemption from an NPA.[9] Such an exemption may define zero-intervention zones on the site, for example.

Major interventions frequently require performance of an assessment of the impacts of the planned intervention on nature and landscape protection interests.[10] For SWR inside a Site of Community Importance or Special Protection Area, it has to be ascertained whether the project impacts on the sites should be assessed.[11] When in doubt about interference with nature and landscape protection interests, it is advisable to consult the project in advance with the applicable NPA.

Construction and reconstruction of SWR should comply with ČSN 75 2410 Small water reservoirs and ČSN 75 2935 Safety assessment of hydraulic structures during floods.[12] For reservoirs with a volume below 5 thousand m^3, the technical standards can be applied proportionately depending on local conditions.

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[7] See Section 4, Para. 2 of NLPA.

[8] Landscape character is defined as the natural, cultural and historical characteristics of a site or area and is protected from activities reducing its aesthetic and natural values (Section 12, Para. 1 of NLPA).

[9] See Sections 48-50 and 56 of NLPA.

[10] See Section 67 of NLPA.

[11] See Section 45h et seq. of NLPA.

[12] Pursuant to Section 4, Para. 1 of Act no. 22/1997 Coll. on Technical Requirements for Products, as amended, the Czech Technical Standards are not generally binding. However, a specific provision of a legal regulation may refer to a specific ČSN, thus making it binding for the specific case.

The most important SWR document is the water handling permit issued by the applicable water authority under the Waters Act.[13] SWR documentation includes service regulations or operational rules, the contents and compositions are governed by **Decree no. 216/2011 Coll. on Requisites for Handling Rules and Operating Rules of Hydraulic Structures**, as amended, and by classification of the hydraulic structure in a category in terms of safety as per **Decree no. 471/2001 Coll. on Technical and Safety Supervision over Hydraulic Structures**, as amended.

Each SWR requires periodic maintenance throughout its service life, and the hydraulic structure owner/operator has to provide qualified operating staff, who follow the operational rules or service regulations in force. The hydraulic structure service regulations describe the frequency of periodic inspections of the reservoir,[14] carried out by an authorized person with qualification for the purpose.[15]

The hydraulic structure owner has to maintain the hydraulic structure in the proper condition and perform other duties under the Waters Act (notably Section 59).

When removing sediment from the SWR, it has to be noted that removed sediment may be considered waste under **Act no. 541/2020 Coll. on Waste**, as amended, and **Decree no. 273/2021 Coll. on Waste Management Details**, as amended. At the same time, **Decree no. 257/2009 Coll. on use of sediments on agricultural soil**, as amended, can be followed under specific conditions.

2 Definitions

2.1 Small water reservoir

2.1.1 Small water reservoir (SWR) is a hydraulic structure[16] used for impounding and accumulation of water.

2.1.2 A small water reservoir is a reservoir that has to meet the following limits according to ČSN 75 2410:

- the storage volume up to standard water level is less than 2 million m^3;
- the maximum depth of water in the reservoir is less than 9 m.

2.1.3 The water levels in reservoirs are specified by ČSN 75 2405 Water management analysis of reservoirs. The following water levels are important for nature-friendly SWR:

- permanent-storage level,

[13] See Section 8 et seq. of Waters Act.

[14] See Section 61 of Waters Act.

[15] See Section 61, Para. 14 of Waters Act in conjunction with Decree no. 471/2001 Coll.

[16] For a definition enumeration of hydraulic structures, see Section 55 of the Waters Act.

- normal water level,
- design flood water level ,
- maximum permissible water level.

2.1.4 Technical requirements for hydraulic structures are defined by Decree no. 590/2002 Coll., on Technical Requirements for Hydraulic Structures, as amended. For the purposes of the Decree, the design flood discharge and check flood discharge are specified among other things. The design discharge is the discharge used for designing the hydraulic structure and its parts with required periodicity; the maximum check flood discharge is the discharge occurring during a natural flood with required periodicity.

3 Information for SWR design

Preparation for SWR design has to have available necessary background information, characterizing the site and usable for a basic analysis of conditions and needs for designing and implementing the SWR. It is important to clearly define the SWR purpose and functions already during planning.

3.1 SWR purpose

3.1.1 Under the present standard, nature-friendly SWR refers to:

- landscape-forming reservoirs in open country (improvement to landscape water balance, creation of PLF, creation of biotopes for organisms),
- landscape-forming reservoirs in urban areas (improvement to environmental quality of settlements, particularly improvement to microclimate, biological, recreational and aesthetic functions),
- nature-friendly reservoirs for various purposes (e.g., firefighting, irrigation).

3.1.2 Small water reservoirs are typically multi-purpose (water accumulation, ecosystem functions, extensive pisciculture, unorganized recreation, etc.).

3.1.3 The primary purpose of landscape-forming reservoirs is protection and promotion of near-natural aquatic habitats, protection and strengthening of biodiversity and organisms bound to water.

3.2 Suitability of SWR construction

3.2.1 Evaluation of background information and surveys for SWR design includes an assessment of suitability and effectiveness of the reservoir construction, and if its effectiveness is proved, a suitable design has to be chosen (through-flow or not-through-flow reservoir, etc.), including assessment of historical data. With a view to the Strategy for Passability of the River Network of the CR, defining priority migration corridors, it is possible in justified cases to make bypassed SWR, which will not constitute a migration barrier (longitudinal slope, distributor, sanitary discharge).

3.2.2 The assessment of the suitability and effectiveness of reservoir construction is based on a comparison of the present ecological value of the site with the conditions after its implementation. The choice of a site for reservoir construction is only justified where the present ecological status of the site will increase as a consequence of the SWR construction. Unsuitable sites for reservoir construction are floodplains with high-quality meadow vegetation, riparian forest, wetland areas or natural or near-natural watercourses beds, where the SWR would constitute a new migration barrier.

3.2.3 The choice of dam profile is based on the primary purpose of the reservoir and the respective watercourse valley morphology. Narrow valleys requiring shorter dams have to have higher dams to retain the necessary amount of water. Moreover, narrow valleys with steep slopes typically do not allow suitable shaping of the shoreline, prohibiting the desirable development of a littoral zone, and deeper water in the reservoir precludes warming of the water column even in summer. On the contrary, shallow reservoirs with a large surface area are severely burdened by evaporation from the free water surface and any introduced sediment rapidly silts the reservoir and gradually transforms it into a wetland.

3.2.4 The field survey has to evaluate the land use in the surroundings in terms of possible erosion washout into the reservoir, look out for increased erosion processes and presence and functionality of drainage systems, if any, on and around the future reservoir site.

3.3 Natural scientific survey

Before starting any design work, it is necessary to carry out a natural scientific survey, at least in the form of an initial site situation survey.

3.3.1 The natural scientific survey shall be made by a natural science expert. The survey outcome is a report containing information about the biotopes located on the site, possible effects of the proposed design on the ecological status of the site, the specially protected species identified on the site, and design considerations to prevent damage to existing valuable natural biotopes.

3.3.2 The natural scientific survey shall include information about the species composition and condition of the fish community on the site and ichthyofauna of the watercourse in question, and fish migration conditions. For a through-flow water reservoir, the natural scientific survey shall include an ichthyological survey of the watercourse on the water reservoir construction area.

3.3.3 The natural scientific survey shall also include an assessment of the effects of SWR construction on the water bodies and the area that would be affected by the SWR (e.g., hydrological conditions during filling).

3.4 Geodetic information

Geodetic topographic and altitude survey using the S-JTSK coordinate system connected to the national Bpv altitude system.

3.5 Geological engineering survey

The survey provides an overview of the composition of the geological profile of the site (soil properties in terms of permeability, stability and carrying capacity), depths of the layers and groundwater levels, material for dam construction, etc.

3.6 Hydrological data

Based on hydrological data, it has to be assessed whether the SWR can be operated on the site in light of the hydrological conditions and water management design. Notably, it is necessary to assess the speed of filling, water replenishing in drought periods, water level fluctuation in the course of the year (e.g., assess whether the reservoir will dry up and whether water level fluctuation in the course of the year is permissible).

3.6.1 The hydrological data serve the design of the reservoir functional structures, particularly the capacity of the safety spillway and the minimum residual flow rate in the watercourse downstream of the dam.

3.7 Information for water handling in the reservoir

3.7.1 The minimum residual discharge (MRF)[17] is specified in the water handling permit decision in force, or has to be determined in accordance with the applicable Ministry of the Environment Methodological Instruction,[18] or a legal regulation in force at the time of making the project documentation.

3.7.2 The SWR service regulations, if required, have to contain rules for ensuring the MRF and specify the minimum water level in the reservoir, below which the water cannot be discharged to improve the discharge downstream to ensure survival of aquatic organisms (permanent-storage level). If the water level in the reservoir decreases to this level, the MRF downstream can be only equal to the water inflow into the reservoir.

3.7.3 Water level fluctuation in the reservoir can also be affected by water withdrawal (e.g., for irrigation, particularly in combination with the high evaporation rates, energy use, etc.). Water withdrawal rules are specified in the water handling permit, and the rate of water level decrease must not endanger the stability of the dam body and reservoir banks. Significant water level fluctuation in the reservoir has a negative effect on the SWR ecosystem and plant and animal species present in it.

[17] See Section 36 of Waters Act: *Minimum residual flow rate is a surface water flow rate that enables general handling of surface water and ecological functions of the watercourse and considers the possibility of recreational navigation.*

[18] Ministry of the Environment Water Protection Department Methodological Instruction on Minimum Residual Flow Rates in Watercourses (MoE Newsletter 5/1998.

4 Designing a new SWR

The design for a new SWR encompasses the design for the dam, functional structures (bottom outlet, safety spillway, filling structure, bypass), the shape of the inundated area, littoral zone, reservoir protection from silting with sediment, and placement of shore vegetation.

4.1 Dam

4.1.1 SWR dams are earthen, homogeneous or non-homogeneous. The specific type is chosen depending on the earth material available on the site.

4.1.2 The dam axis may be straight or arched. The dam stability is not affected by the plane view shape of the dam axis; a curved dam does not disrupt the landscape character. Reservoirs enclosed in dams along the greater part of the perimeter (U-shaped dam) are inappropriate, particularly due to the high costs of dam construction.

4.1.3 The dam height is the sum of the depth of the permanent retention volume, the storage volume and flood storage volume area, and the safety elevation of the dam crest above the maximum water level. The elevation of the dam crest above the maximum water level is necessary to prevent waves flow over the crest. For dams carrying a public road with car traffic, the dam crest elevation has to be at least 0.60 m (up to the carriageway base level). If the dam carries a footpath, or only occasional traffic from reservoir manager's vehicles is expected, it is advisable to reduce the dam crest elevation.

4.1.4 The dam shape is typically a trapezoidal; the slope gradients are specified in ČSN 75 2410 depending on the type of earth material used (the average gradient is 1:3 for the upstream slope and 1:2 for the downstream slope). If enough earth material is available (e.g., from excavating the inundated area), it is desirable to reduce the downstream slope gradient (up to 1:10) for better integration of the dam into the landscape and vegetation possibility on the downstream slope. In that case, it is necessary to pay increased attention to the dam drainage system design, to make it meet the requirements for the depression curve. With a greater dam height (above 5.0 m), the downstream slope can be graded with a berms.

4.1.5 SWR efficiency is specified by the ratio of the water storage volume to the volume of earth material used for the dam construction; the optimum ratio is 10–15 or higher. This ratio can be achieved usually for larger reservoirs; commonly designed reservoirs have to achieve at least a ratio of 3.

4.1.6 The width of the dam crest depends on the dam stability needs, compaction technology and the use of the dam crest (it equals at least with road width for crests equipped with a road, and is at least 3.5 m for crest with occasional use for cars). For dams without a road higher than 5.0 m, the minimum width is 3.0 m; the crest width can be less than 3.0 m for lower dams. The carriageway on the dam crest is drained inclined by a 3% gradient towards the reservoir, while asphalt surfaces on the dam crest are designed with a 3% gradient towards the downstream slope.

4.1.7 The upstream slope is reinforced primarily to protect the dam from the effect of waves. Priority materials include stone riprap and rubble masonry. The reinforcement thickness is approx. 0.30–0.40 m (optimum stone size 63–300 mm); alternatively, dry masonry pavement. The downstream slope is reinforced preferably with grass. The upstream slope reinforcement should ideally reach 0.30 m above the normal water level; it should be up to the maximum water level for larger reservoirs with significant wave action. Local stone material has to be used with priority for the upstream slope reinforcement.

For reinforcement with respect to Eurasian beaver action, see chapter 4.6.8.

4.1.8 Rules for grass sowing and tree planting on the dam crest and along the shore line are described in chapter 4.5.

4.2 Bottom outlets

Bottom outlet is used for controlling the water level in the reservoir and complete emptying of the dam, not for water level control during a flood.

4.2.1 The most common bottom outlet type is the monk, typically with two sluice board walls, allowing for draining water from the bottom or from the water surface.

4.2.2 The monk tower can be made of concrete, quarry stone or wood. Nature-friendly wooden monks, commonly used historically, have a limited service life and their functionality is endangered by possible Eurasian beaver action. The disadvantage of monolithic concrete and stone monks is their bulky size. Prefabricated concrete towers with thin walls and significantly smaller tower dimensions are more suitable. Such prefabricated monks can be lined with quarry stone (25 cm thick) or hardwood planks at least 5 cm thick. Such surface finish requires more frequent inspection and maintenance. The monk tower head need not be at the dam head level; approx. 10 cm above the maximum water level suffices.

4.2.3 The drain pipelines from the monk can be made of concrete, fibreglass, earthenware or plastic. Plastic pipelines are mostly used nowadays as they allow easy handling and connection of segments (PE or PP; PVC pipes are inappropriate). The minimum profile of the drain pipeline is DN 300; the drain pipe diameter has to be designed to carry the maximum discharge without pressure flow. The longitudinal gradient of the pipeline matches in general the valley gradient. The drain pipeline from the monk is encased in concrete along the entire length of passage through the dam, using cast hydraulic concrete, ideally with reinforcement and an anti-seepage coller.

4.2.4 The joint between the monk tower and the head of the drain pipeline has to be made extremely well. It is advisable to seal this joint with a flexible sealant for an expansion joint between the structures; expanding foam or silicone are absolutely inappropriate.

4.2.5 The drainage pipeline outfall below the dam has to be stabilized with a wall of quarry stone joined with cement mortar; using concrete for the wall is inappropriate. The need to dissipate the excess flow energy at downstream of drainage pipeline outlet has to be assessed, and suitable measures properly designed.

4.2.6 Access to the monk tower head for handling the sluice boards has to be provided either via an access footbridge or by embedding the monk tower in the dam. The access footbridge structure depends on the footbridge length, which determined by the dam height and the upstream slope gradient. For higher dams, it is advisable to embed the monk tower in the dam and stabilize water inflow into the monk with inflow wings. Pillars supporting the footbridge set into the upstream slope of the dam are inappropriate. If the distance from the dam crest to the monk tower is short, the footbridge can be omitted and access provided along the dam slope. In order to prevent unauthorized access to the monk tower and integrate it better into the landscape, a footbridge made of composite or steel elements without a railing can be mounted approx. 10 cm below the normal water level.

4.2.7 The footbridge load-bearing structure is ideally made from hot galvanized steel beams. The railing can be either steel or wooden. If the footbridge is not mounted over the spillway floor, a railing on one side is sufficient.

4.3 Safety spillways

Spillways are used for safe passage of flood discharges through the reservoir. The SWR spillway should be ungated and the spillway head must not bear a bar screen that would reduce its flow capacity (a bar screen can be mounted ahead of the spillway edge, determining its length with a view to local loss).

4.3.1 The design and check flood discharges for dimensioning the spillway are specified in ČSN 75 2935 Assessment of hydraulic structures safety during floods, depending on the hydraulic structure category. Since the greater part of reservoirs designed at present are category IV, the design flow rate is Q_{100} (prevailing third-party losses to other risk bearers outside the owner, user or investor), or Q_{50} and Q_{20} (in the case of possible losses only to the reservoir owner, other losses being insignificant).

The design discharges of Q_{50} and Q_{20} can be used after proper justification and detailed calculation (e.g., based on downstream valley configuration, value of downstream territory, area without buildings and infrastructure, etc.). In justified cases, the loss potential assessment can stop at the assessed hydraulic structure dam profile, considering only losses to the structure itself and losses of utility. This can be applied where the damage concerns mostly the hydraulic structure dam itself and other losses are insignificant.

4.3.2 The spillway type is chosen depending on the size of the design and check flood discharge values (see 2.1.4), dam height and terrain configuration. A crest or fountain spillway can be used with lower design discharge values and smaller dam heights; a side weir is more suitable for higher discharge values and greater dam heights.

4.3.3 A crest spillway may comprise a trapezoidal depression with slope gradients of 1:5 to 1:10 (to permit passage of pedestrians or agricultural machinery). The spillway surface and slopes are usually divided into sections by concrete stabilization sills lined on top with quarry stone or by wooden beams; the area between them paved with quarry stone laid in concrete, or dry-laid wedged quarry stone in justified cases. It is advisable to cover the spillway surfaces with soil and grass.

4.3.4 A fountain spillway or side weir should be made of monolithic concrete to ensure water-tightness of the structure. The visible parts should be lined with quarry stone 25 cm thick.

4.3.5 With lower design discharges and gentle gradients of the dam downstream slope (1:5 or gentler), the channel from the side spillway can be designed as a depression reinforced with quarry stone riprap.

4.3.6 The stream channel adjacent to the outlet and spillway should be reinforced with stone riprap (each stone weighing 200–500 kg) with wedging (flexible reinforcement); laying into concrete is inappropriate. Suitable measures to dissipate the energy of the flowing water should be designed as needed.

4.3.7 The emergency spillway can be designed only as a complement to increase the reservoir safety.

4.3.8 Combining the outlet and spillway structures is not appropriate due to the structural bulkiness; it can be done in justified exceptional cases in reservoirs with a larger surface area.

4.4 Reservoir area

4.4.1 The reservoir area shape should match the natural character of the floodplain. This can be achieved by both suitable choice of the dam profile and suitable shaping of the reservoir shoreline. Regular straight lines are absolutely inappropriate; indented shores with bays and peninsulas are ideal. The same rules apply to bank gradients, which should be diverse and gentle. The longitudinal gradient of the reservoir bottom should match the longitudinal gradient of the floodplain. The overall bottom design should permit complete drainage of the bottom after emptying the reservoir.

4.4.2 A littoral zone has to be retained or created in the inlet part of the reservoir with a water depth up to 0.6 m and a gentle slope of the shore. The littoral zone should make up ideally 20% of the reservoir surface area; the minimum size should be

15%. The littoral zone enables development of species-rich littoral and macrophytic vegetation, thus establishing a suitable biotope for fish, water birds, amphibians and aquatic invertebrates.

4.4.3 Dead-end pools can be formed near the inlet outside the littoral zone, fed via the increased water table; it is desirable for some not to connect with the reservoir water surface at the maximum water level (rules for designing pools are specified in SPPK B02 001 Creation and restoration of pools.)

4.4.4 For larger reservoirs, the inlet section of the source watercourse can be designed with multiple branches with higher flow rates or calmer conditions.

4.4.5 Larger and shallower reservoirs can be designed with an islet inside the reservoir area. When designing an islet, its purpose is critical. Islets for boosting nesting options for water birds are designed mostly low and flat, with gentle shores, free of vegetation and with a surface adjusted to the target species composition. Islets for improving the landscape and aesthetic value of the area may be designed with tree and shrub vegetation; in other cases, leaving them up to spontaneous succession is advisable.

4.5 Vegetation on dams, shore vegetation and dead wood

4.5.1 Vegetation can be planted on the downstream dam slope so that roots do not grow into the toe drain. Planting cannot be done near concrete and masonry structures. It is desirable to use long-lived trees (e.g., pedunculate oak); inappropriate trees include conifers (notably spruce), fruit trees, willows and poplars. Planting of introduced species of trees must be ruled out completely. Planting of shrubs is not recommended, as they preclude visual inspection of the downstream dam slope. If the downstream slope is graded with a berm, the level bank area can be used for vegetation planting.

4.5.2 If there are existing tall trees along the reservoir perimeter (e.g., willows, alders, etc.) it is advisable to retain the original vegetation or to create a peninsula or islet that is not inundated. It is advisable to leave the environment to its natural succession.

4.5.3 Shore vegetation (trees and shrubs) as to comprise locally appropriate species, and introduced species have to be ruled out completely. It is not appropriate to plant trees where the littoral zone is established. The littoral zone should receive maximum sunshine.

4.5.4 The planting should suitably complement existing vegetation and should ideally be planned in groups, using various vegetation types with non-uniform spacing, leaving parts of the shoreline free of vegetation (sunshine and shade for the water surface, views of the water from around the reservoir). Accompanying vegetation planting has to include protection from damage by farm animals or game (sleeves and posts), and receive follow-up management (planting rules are specified in SPPK A02 001 Planting of trees).

4.5.5 Finishing operations typically include covering the dam crest and downstream slope with humus and grass (grassing rules are specified in SPPK C02 007 Grasslands). It is not appropriate to cover the banks with humus and apply standard grass seed to them. The ground should only be levelled and left up to natural succession, particularly in inundated floodplains.

4.5.6 Any remaining wood matter cut during the reservoir construction, such as larger trunks and stumps, can be used in the littoral zone, embedded in the reservoir bottom and banks as dead wood for improving the site biodiversity (shelters).

4.6 Additional measures

Additional measures for reservoir design may include grassy strips, low erosion-protection embankments, or revitalization of the adjacent section of the feeder watercourse and fish harvesting equipment as part of nature-friendly management (fishing pit, tub area, staircase to the fishing pit or vehicle ramp into the reservoir).

4.6.1 Grassy strips (buffer zone), low erosion-protection embankments or rows of boulders along the reservoir perimeter serve protection from sediment transport from adjacent land, mainly arable land, and from ploughing up the grassy strips. The grassy strips should be at least 15 m wide, and can be placed at an advantage between the normal water level and the maximum water level (the reservoir owner should have a proper use title for the land in this area).[19] With good maintenance of these areas, the grass cover will intercept soil particles transported from adjacent land into the reservoir (grassing rules are specified in SPPK C02 007 Grasslands).

4.6.2 This strip of permanent grassland can also be used for planting accompanying vegetation around the reservoir (planting rules are specified in SPPK A02 001 Planting of trees). The grassy strip should incline gently towards the reservoir to ensure sedimentation of transported soil particles.

4.6.3 The erosion-protection embankments have to be stabilized to prevent their washing into the reservoir. Water intercepted outside the embankments has to be appropriately directed under the dam; with suitable infiltration conditions, it may be infiltrated to the soil outside the embankments.

4.6.4 A suitable and supported addition to reservoir construction is revitalization of the watercourse downstream of the reservoir, and upstream as the case may be. Such projects may include implementation of pools downstreams of the dam, with little extra work in places where earth for the dam construction was excavated. Such pools will be fed by the groundwater (rules for pool design are specified in SPPK B02 001 Creation and restoration of pools). Pools downstreams of the dam must not endanger the filtration stability of the downstream slope of the dam and the drainage effect of the toe drain.

[19] I.e., proprietary title or encumbrance with servitude or use title based on an agreement (typically lease or tenure) pursuant to Act no. 89/2012 Coll., the Civil Code, as amended.

4.6.5 The most valuable part of the reservoir from the point of view of natural sciences is the littoral zone with a water depth up to 0.60 m and a gentle bank gradient. This area is important for development of aquatic macrophytic vegetation, bird nesting and shelters for other animals. It is a calm zone inaccessible for people and predators. The recommended area of the littoral zone is 20% of the total reservoir surface area (at least 15%). It is advisable to segment the shoreline and connect the littoral zone smoothly to the surrounding terrain. The connectivity of the water area to the surrounding terrestrial area is important for performance of ecological stabilization functions of the reservoir by establishing wetland areas between water and terrestrial area. The terrestrial part of the littoral comprises the ground around the reservoir lying up to 10 cm above the water level. The littoral zone area is left up to spontaneous succession; it is not advisable or effective to plant wetland vegetation there. In larger reservoirs, the littoral zone can be divided from the reservoir with a strip of raised bottom to prevent fish from entering it.

4.6.6 If large stones (boulders) are found during the reservoir construction or reconstruction, they should be used in the inundated area or the littoral zone for biotope establishment.

4.6.7 A simple fishing pit can be built near the outlet for harvesting the fish in the reservoir. Alternatively, grooves for bar screen and gate can be built in the outlet bed and fish can be harvested under the dam (rules for nature-based fishpond management are specified in SPPK B02 005 Nature-based fishpond management).

4.6.8 Due to the expanding territory of the Eurasian beaver, sites with expected activity and influence (life manifestations) of the Eurasian beaver on the SWR condition have to adopt measures for protection of SWR technical structures. Rules for coexistence with beavers are specified in “Průvodce soužití s bobrem” (ČZU, 2016).

To prevent gnawing of trees, suitable composition of retained and planted vegetation has to be chosen, accompanied with technical measures (enclosures, fences, scent fences).

To prevent digging of burrows, it is advisable to reinforce the dam with massive stone riprap, or lay stones that weigh over 40 kg and gravel of minimum fraction size 64/125 and layer thickness of 40 cm in combination with wire mesh (wire thickness at least 2 mm and max. mesh size 10×10 cm), which will discourage beavers from digging. The effectiveness of this measure is reduced by the limited service life of the wire mesh. A gravel filter (frequently in multiple layers) has to be built underneath any type of reinforcement that will prevent washout of dam material. The reinforcement has to be founded on a riprap footing at the slope foot level and, to protect it from temporary beaver shelters during floods, it should go all the way to the maximum design water level.

To prevent limited functionality of technical elements of the SWR, it is advisable to install beaver barriers in front of the structures to prevent beavers from entering them and manipulating the water level. The protective cages are mostly made of squared timber with weldmesh embedded in the bottom and fastened to the structure to prevent digging under it or pulling it away. It is advisable to install bar screens at the spillway, or a structure similar to the that used formonks. If access is also possible from the dam crest, the spillway has to be fenced completely to prevent it being dammed over.

5 SWR reconstruction

SWR reconstruction refers to modification or reconstruction of functional parts of the SWR that are operated, destroyed or damaged and do not meet requirements for their functionality and safety. SWR reconstruction involves changes to parameters of the functional structures (dam, outlet, spillway). From the point of view of the Building Act, they comprise changes to a completed structure.[20]

SWR revitalization is activity that restores the ecological stabilization functions of a PLF.

SWR reconstruction design shall follow rules specified above; this section only specifies differences arising from SWR reconstruction compared to new SWR construction.

5.1 Reasons, purpose and extent of SWR reconstruction

5.1.1 Reasons for reconstruction of an existing reservoir may include fundamentally changed runoff conditions in the catchment area to the dam profile (caused, e.g., by changes in land use, deforestation, increase in collection area – reclaimed spoil tips, etc.), unsatisfactory condition of the dam or functional structures, reconstruction of extinct reservoirs (broken or demolished dams) or reduced reservoir storage area due to silting or biomass decay, causing a reduction to the ecological stabilization functions of the prominent landscape feature.

5.1.2 The effectiveness of the reconstruction has to be assessed before renovating the reservoir. In the case of restoration of a destroyed reservoir, it is advisable to find out the reason why it was decommissioned (flooding problems, silting, poor technical state of the dam or functional structures). In addition to surveys specified in chapter 3.2, the data for the assessment include other surveys, e.g., geotechnical dam survey, dimensions of the dam and functional structures. If the location of the former (decommissioned) reservoir currently supports a more valuable biotope (e.g., species-rich wetland, riparian forest, etc.), SWR restoration is inappropriate in terms of nature protection.

5.1.3 From the technical point of view, SWR reconstruction and revitalization is more advisable in summer, unless there is no better time (particularly when renovating partially functional SWR) in light of protection of existing biota (e.g., bird nesting).

[20] Changes to a completed structure comprise height extensions, side extensions and structural modifications that retain the outer footprint and elevation of the structure (Section 2, Para. 5 of the Building Act).

For reservoirs with a water level, it is advisable to shift the start of works until early September (completion of amphibian development).

5.2 Dam

5.2.1 If the collapses occur on the dam, the reason has to be established first. If the reason is a cavity inside the dam (e.g., where the bottom outlet pipeline passes through it), it is necessary to open the dam, repair the reason for the failure (seal pipeline joints, encase the pipeline in concrete, or replace the whole bottom outlet), then place dam earth in layers with perfect compaction and interlinking with the existing dam. If the dam failed due to collapsing beaver dens, the proper measure is to fill in and destroy existing dens and collapses, reducing the risk of further material damage. If the dam failed due to insufficient compaction, remove the top layer of earth and add new earth, compacting it perfectly.

5.2.2 The same procedure applies to reconstruction of the dam crest. Rut tracks and other surface unevenness in the dam crest have to be immediately filled in with suitable earth and compacted.

5.2.3 Cracks in the dam, typically caused by wave action and water level fluctuation in older reservoirs without a reinforced upstream slope, have to be repaired by removing the eroded part of the earth and gradually adding earth in layers of optimum thickness, compacting them. The areas where existing and new earth join have to be compacted thoroughly for a good connection. The new slope has to be reinforced; this requires use of natural, mostly local materials; do not rehabilitate the dam with concrete or pavement laid in concrete (as per 4.1.7).

5.2.4 If the bottom outlet pipeline needs replacement, dig through the entire width of the dam perpendicular to its axis. After eliminating the pipeline defect or replacing it, the dam has to be resealed with suitable earth (renovating the sealing component as necessary). Earth has to be placed in layers and compacted thoroughly. The extent of the defect in the outlet drainage pipeline can be established using a camera. In some cases, leaky joints or local defects can be resolved without digging the dam open, e.g., by chemical injection, short connecting pieces or pulling a longer repair sleeve into the pipeline.

5.3 Outlets

5.3.1 When renovating historical outlet equipment, consider whether to change the outlet type (e.g., replace blade or pivot valve with conventional monk with a) or renovate it using a historical type. However, the consideration whether to retain historical equipment has to be based primarily on hydraulic structure safety and equipment functionality in light of modern-day requirements (minimum outlet pipeline diameter, tightness of the monk-pipeline joint, ability to ensure MRF downstream).

5.3.2 Mere replacement of the outlet closing device using a concrete monk connected to an original wooden pipeline is not recommended, as it may damage the pipeline at the joint with the tower due to the greater weight of the concrete tower. When retaining an original wooden drainage pipeline, it is more appropriate to use a wooden monk for a flexible joint of both parts.

5.3.3 Complete replacement of the outlet (closing device and outlet pipeline) is of course a more complex and costly implementation, but with much higher certainty. The procedure for opening the dam is specified in 5.2.4. A concrete base slab for the drainage pipeline is built on the footing base, the pipeline is laid at the necessary gradient, encased in concrete along the entire length of passage through the dam as per 4.2.3, and the dam is sealed as per 5.2.4.

5.4 Safety spillway

5.4.1 When renovating the reservoir spillway, it has to be considered carefully whether a complete reconstruction is necessary or a repair suffices. When renovating the spillway structure (changing its dimensions), ČSN 75 2410 and ČSN 75 2935 have to be complied with, specifying design and check flood discharge values for sizing the spillway structure dimensions specified in 0.

5.4.2 In some cases, only maintenance of the spillway will be necessary (reinforcement of the edge or spillway outlet, removal of vegetation from the flow profile); then the rules of the above technical standards can be ignored.

5.4.3 If the spillway structure has to be renovated, consider the type of the new spillway structure. A side or fountain spillway should be preferred with higher design and check flood discharge values due to the longer spillway edge.

5.4.4 The materials used for reinforcing the spillway edge, chute and outlet have to be natural (typically pavement made from local quarry stone); large-scale concrete reinforcement is prohibited. The spillway head edge should be reinforced with pavement made of quarry stone laid in concrete, because if only a part of dry pavement is washed out, the whole structure is destroyed rapidly; moreover, with dry pavement reinforcement, water can flow out under the pavement structure even at lower flood flow rates and thus wash out the pavement substrate. Stones cut to size, mounted on steel spikes, can be used as reinforcement for the spillway edge.

5.4.5 To increase the dam safety, the main spillway can be complemented with an emergency spillway, located at the dam end, left or right.

5.5 Accompanying vegetation

5.5.1 Reconstruction of accompanying vegetation should be governed by a survey and evaluation of existing vegetation. High-quality and promising trees have to be retained, including along the SWR dam.

5.5.2 Reconstruction of accompanying vegetation consists in removing damaged trees and shrubs, particularly along the dam crest (complicating vehicle traffic), on the water-facing slope (damage to slope reinforcement and potential root growth through the dam, producing seepage paths), and on the downstream slope at the toe of the dam (root growth inside the toe drain). Restoration of accompanying vegetation shall comply with rules set out in 4.5.

5.5.3 When renovating existing accompanying vegetation along the SWR dam, the retained vegetation should have a linear shape and there should be enough space between the trees and under their crowns for pedestrians and vehicles.

5.5.4 To protect the reservoir from sediment transport from land around the reservoir, it is advisable to add protective grassy strips, low erosion-protection embankments and, as necessary, rows of boulders along the reservoir shoreline, and add vegetation to those components. The rules for the uses are specified in 4.6.

5.5.5 Occasional removal of dead or damaged vegetation can be handled as part of maintenance.

5.5.6 If there are trees on the dam crest, their root tapers must not be buried, and the requirements of SPPK A01 002 Protection of woody plants during development activities have to be complied with.

5.5.7 Rules for accompanying vegetation along reservoir shores are specified in 4.5.3.

5.6 Littoral zone

5.6.1 Reconstruction (modification) of the littoral zone is typically done simultaneously with sediment removal from the reservoir. It consists in segmenting (reduction in some cases) of the littoral zone (segmentation with channels with small through pools, creating an indented shoreline, parallel inlet channels and pools – for the rules, see SPPK B02 001 Creation and restoration of pools). The littoral zone has to be inclined towards the reservoir to prevent any areas without drainage.

5.6.2 Littoral zone reconstruction shall follow rules specified in 4.6.5, 4.6.6, 4.5.6 and in 5.7.8.

5.7 Sediment removal

Removal of sediment from the reservoir (sediment removal) has to be assessed in terms of both need and purpose. The critical factor is positive effect on water quality (reservoir eutrophication) and increased volume of retained water.

5.7.1 First of all, assess the transport of soil particles from the reservoir catchment area and whether it is realistic to resolve erosion processes on farmland in the catchment area. Based on that, consider how long it will take for the reservoir to silt up again. Ideally, the sediment removal from the reservoir should be combined with the ongoing comprehensive land reform process, particularly implementation of proposed erosion-protection measures.

5.7.2 As part of the sediment removal, always consider the ability to reduce the sediment inflow. A sedimentation pool should be built at the reservoir inlet.

Sediment should then be removed from the pool periodically. The extraction frequency depends on the erosion and transport processes in the catchment area.

5.7.3 To assess the sediment quality, and thus the options for reusing the extracted sediment, a sediment analysis under the legal regulation in force[21] is necessary.

5.7.4 After the sediment removal, the reservoir bottom has to be inclined towards the drainage ditch, so that the bottom can dry after emptying the reservoir. When removing the sediment, never interfere with the impermeable bottom layers and form areas without drainage.

5.7.5 If the reservoir is left dry over the summer to dry the sediment properly, it is desirable to build a few smaller pools in the inlet section as a substitute biotope for aquatic animals, particularly amphibians.

5.7.6 The sediment removal start and end dates have to be adjusted primarily to the results of the natural scientific survey.

5.7.7 The sediment extraction technique (dry or wet) has to be decided based on the quantity of the sediment and the existence of areas for sediment dehydration (lagoons). The extraction technique in the inundated area and the littoral zone has to prevent damage to valuable biotopes. In justified cases, in nutrient-poor area, where the proper functioning of the aquatic ecosystem has to be initiated (started), a 10 cm layer of sediment can be left unextracted in the inundated area.

5.7.8 In the littoral zone, leave an area unextracted that corresponds to 15–20% of the reservoir water surface. Rules for shaping the littoral zone are specified in 4.6.5.

5.7.9 The transition from retained sediment forming the littoral zone to the extracted part of the bottom has to be very gentle (depending on the nature of the sediment), or stabilized in a suitable way to prevent washout of the retained sediment into the extracted area.

[21] Act no. 541/2020 Coll. on Waste, as amended, and its executive decree no. 273/2021 Coll. on Waste management details, as amended, and Decree no. 257/2009 Coll. on Use of sediments on agricultural soil.

6 Annex 1: List of Nature and Landscape Management Standards (Series B – Water in Landscape)

02 001	Creation and restoration of pools
02 002	Renaturisation of the water regime of mires and springs
02 003	Restoration of watercourses and their floodplains
02 004	River management including bank vegetation
02 005	Nature-based fishpond management
02 006	Fish passes
02 007	Construction and reconstruction of small water reservoirs using a nature-friendly approach

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