# The role of the hydrology in wetland ecosystems of Záhorská nížina Lowland

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# Hydrologic conditions of the Záhorská nížina Lowland

- result of the many factors: geologic and tectonic structure, soil and climate conditions,
- cold steppe with the smaller lakes and poor vegetation in the era, when the Alps and Tatra mountains covered glacier,
- appearance of birches and pines after the glacier backdown,
- the Morava river moved to present position, number of dead branches,
- strong wind activity – wet areas overgrowth by the forest vegetation = basis of forest,
- rivers, discharge lakes drained slopes of Small Carpathians, made a way through the sand dunes to the Morava river, filled tectonic decreases by transported materials,

# Hydrologic conditions of the Záhorská nížina Lowland

- wet areas arised in dependence of the geologic structure – impermeable subsoil near the surface
- the wind activity decreased during the next warming – expanded pine – oaken wood,
- stream continued in the formation of terrain morphology – in the period of the high level they flooded dead branches - formation of fen peat sediments
- 16th century – plantation of the pine monocultures


*Floodplain of Morava river*

# National Nature Reserve Zelienka

## Description of the NNR Zelienka

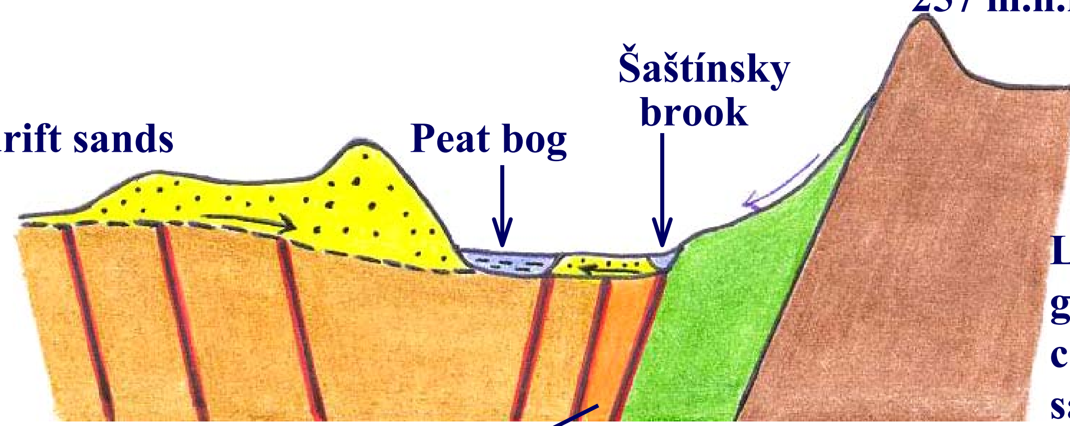
- situated in central part of the Záhorská nížina Lowland,
- part of the Protected Landscape Area Záhorie,
- represents a peat bog community of the relict origin with open water level,
- area: 82,52 ha,
- one of the last well – preserved fen bogs in inter dune area.

## Description of the peat bog in NNR Zelienka

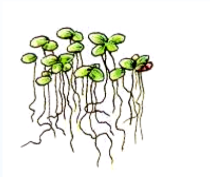
- minerotrophic type,
- dominant association: Alnetea glutinosae,
- area: 60 ha,
- peat thickness: 150 cm,
- Transition to the upland peat – appearance of some bog spaghnum

# WETLAND HYDROLOGY

Geological profile through the wetland area
in NNR Zelienka:



# WETLAND HYDROLOGY



**Wetland water budget in NNR Zelienka:**

$$\Delta V/\Delta t = P - I - ET + G_i - G_o$$

**year 2001:**

$$0{,}07 = 0{,}529 - 0{,}108 - 0{,}739 + G_i - G_o$$

$$G_i - G_o = 0{,}388 \text{ m.}$$

**The change of the water capacity represents 10 000 $m^3$ on the area 124 500 $m^2$.**

**year 2002:**

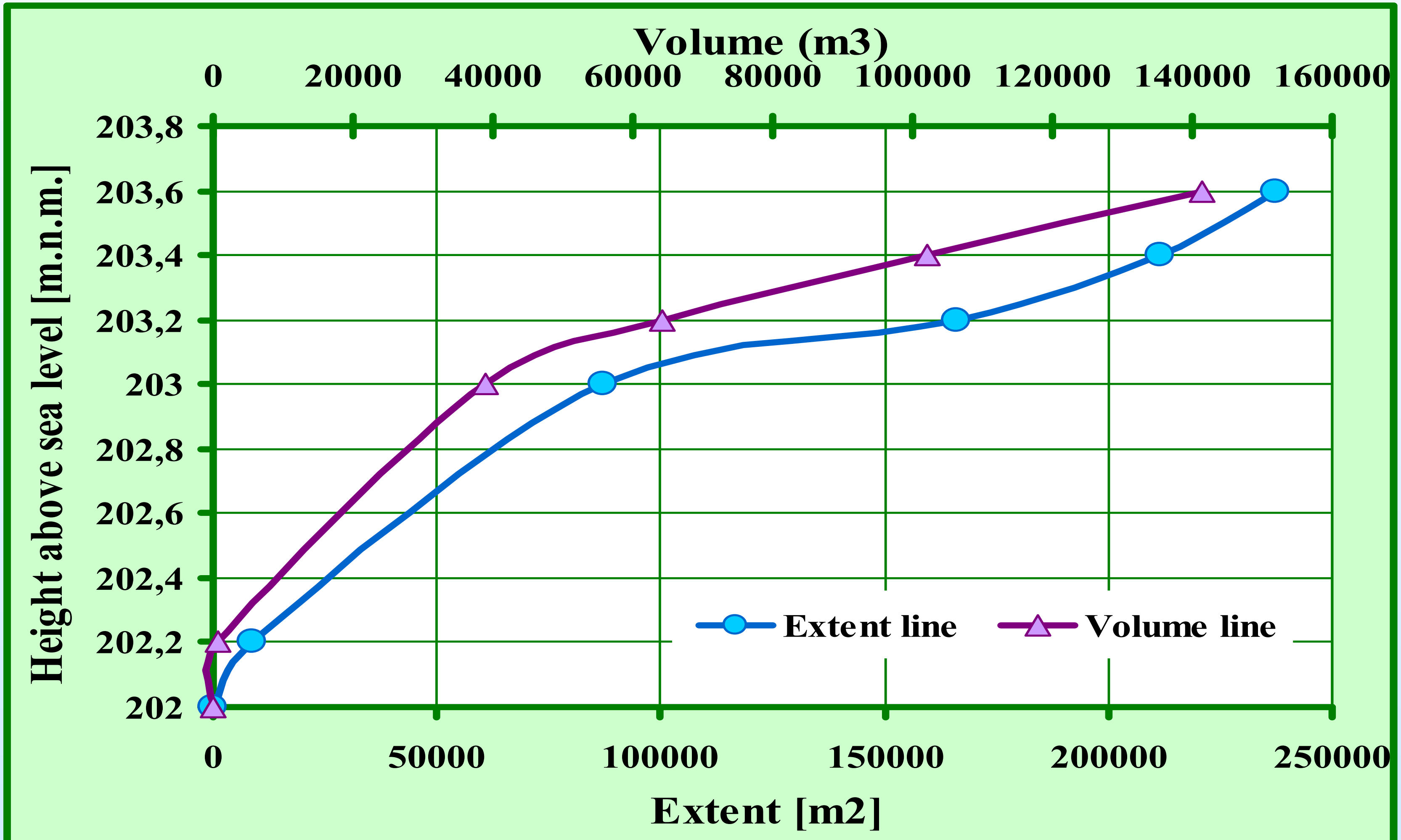
$$0{,}08 = 0{,}707 - 0{,}145 - 0{,}471 + G_i - G_o$$

$$G_i - G_o = 0{,}091$$

**The change of the water capacity represents 14 000 $m^3$ on the area 200 000 $m^2$.**

# WETLAND HYDROLOGY

## Extent line and Volume line of the peat bog in NNR Zelienka



# WETLAND HYDROLOGY

# EVAPOTRANSPIRATION

**In the present there are developed numerous methods of the measurement and computation of evapotranspiration.**

**Evapotranspiration can be determined with any number of empirical equations. One of the most frequently used is Thornthwaite Equation for the potential evapotranspiration.**

$$ET_i = 16 \times (10 \times T_i / I)^a$$

$ET_i$ = potential evapotranspiration for month, mm.mesiac$^{-1}$

$T_i$ = mean monthly temperature, $^{o}C$

$I = \sum_{i=1}^{12} (T_i / 5)^{1,514}$ = local heat index

$$a = (0{,}675 \times I^3 - 77{,}1 \times I^2 + 17{,}920 \times I + 492{,}390) \times 10^{-6}$$

# WETLAND HYDROLOGY

## EVAPOTRANSPIRATION

**Dalton Law:**

$$E = c \times f(u) \times (e_w - e_a)$$

$c$ = coefficient of the aerial mass
$f(u)$ = function of the wind speed
$e_w$ = saturation vapour pressure of wet surface
$e_a$ = vapor pressure in surrounding air

**Penman Equation:**

$$ET = \frac{\Delta H + 0,27 \times E_a}{\Delta + 0,27}$$

$\Delta$ = slope of curve of saturation vapour pressure, mmHg/ $^{o}$C
$H$ = net radiation, cal.cm$^{-2}$.deň$^{-1}$
$E_a$ = term describing the contribution of mas-transfer to evaporation

**Tomlain Equation:**

$$E_0 = \rho D(q_s - q)$$

$\rho$ = air density ( = 1,298 .10$^{-3}$ g.cm$^{-3}$),
$D$ = integral diffusion coefficient
(in winter D = 0,3 cm.s$^{-1}$, in summer D = 0,63 cm.s$^{-1}$),
$q_s$ = measuring air humidity saturated by water vapour at the temperature of the vaporized surface [hPa],
$q$ = measuring air humidity in the meteorological box [hPa].

# Calculation of the Potential Evapotranspiration

**It is important to know the temperature of the vaporized surface $T_w$ in order to $q_s$. If soil surface temperature data is missing, than  is assessed by equation of the surface energy balance:** $B = \lambda E_0 + H + Q$

$B$ = total surface radiation balance [$kcal.cm^{-2}.mes^{-1}$]
$\lambda$ = latent heat of vaporization = $2{,}5.10^3$ $kJ.kg^{-1}$
$H$ = turbulently heat flux between surface and atmosphere [$kcal.cm^{-2}.mes^{-1}$]
$Q$ = soil heat flux [$kcal.cm^{-2}.mes^{-1}$]

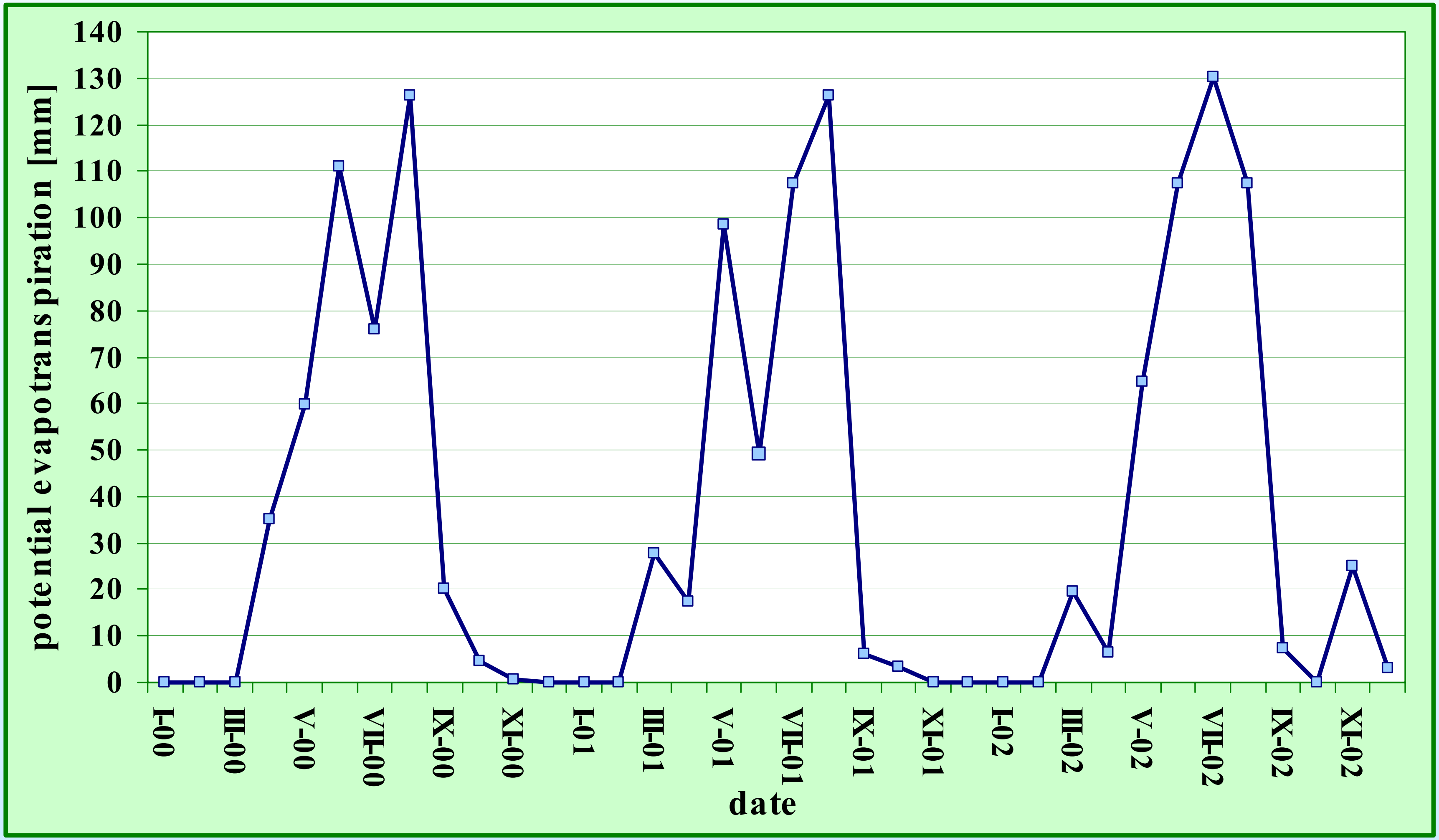
**After substition:** $B = B_0 - 4\varepsilon\sigma T^3(T_w - T)$ $\quad H = \rho C_p D(T_w - T)$

**we get:** $B' - Q = \lambda\rho D(q_s - q) + (4\varepsilon\sigma T^3 + \rho C_p D)(T_w - T)$

$B'$ = radiation balance of the wet surface (lonfwave radiation balance calculated from air temperature) [$kWh.m^{-2}$]
$4\varepsilon\sigma T^3(T_w - T)$ = correction at the difference between temperature of the radiated surface and air temperature
$T_w$ = soil surface temperature [K], $T$ = air temperature [K]
$\varepsilon$ = emissivity (for deciduous wood = 0,97 a for coniferous les and grass = 0,98)
$\sigma$ = Stefan – Boltzmann constant (= $5{,}67.10^{-11}$ $kWh.m^{-2}.K^{-4}$)
$C_p$ = measuring thermal capacity of air at constant pressure [for dry area = 1,004 $kJ.kg^{-1}.K^{-1}$, for humid area = 1,004(1+0,90q) $kJ.kg^{-1}.K^{-1}$]

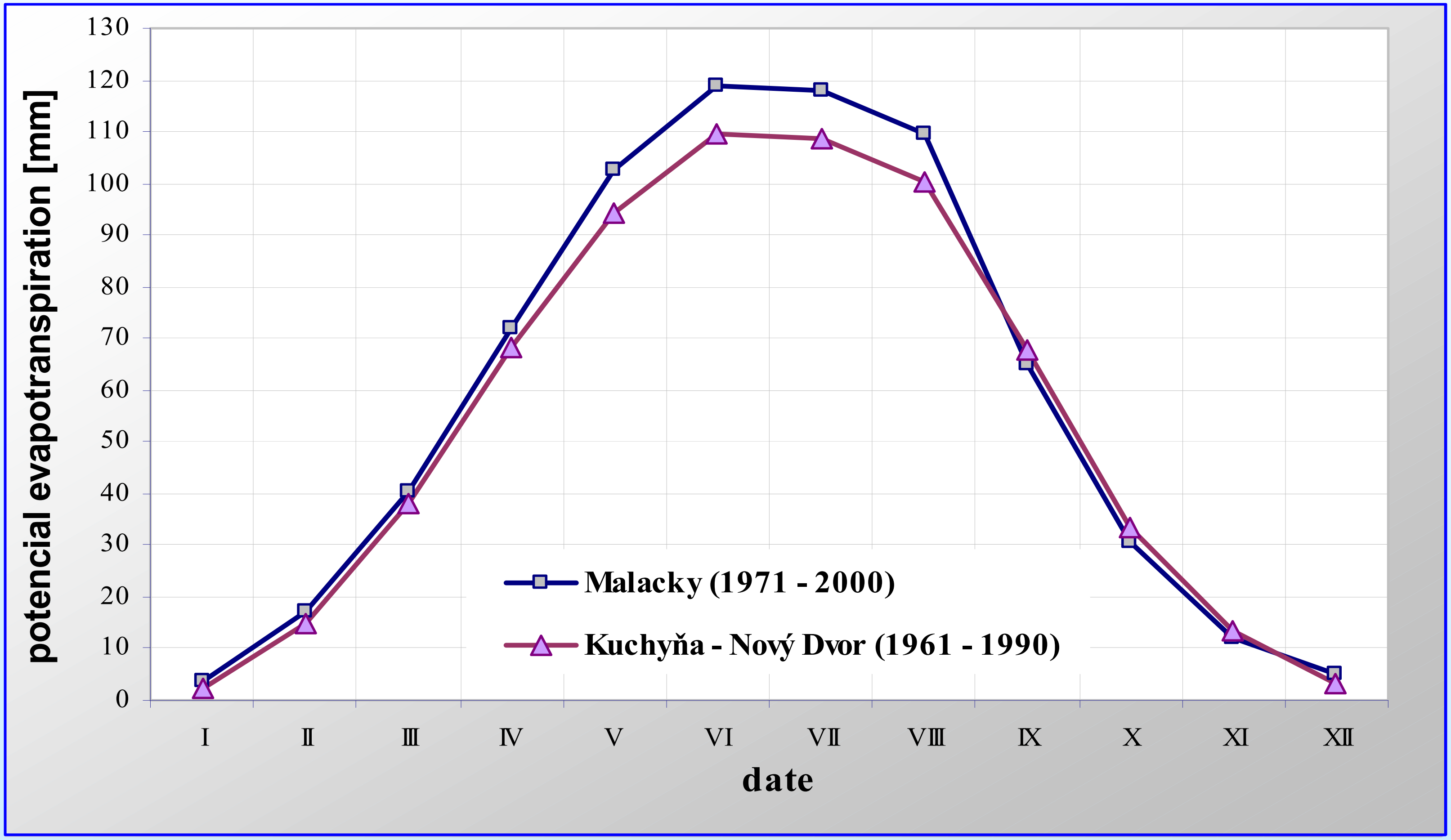
# Calculation of the Potential Evapotranspiration

**Average monthly totals of the potential evapotranspiration during 2000 - 2002 in case of the Meteorological Station Kuchyňa – Nový Dvor:**



# Calculation of the Potential Evapotranspiration

Average monthly totals of the potential evapotranspiration during 1961 – 1990 in case of the Meteorological Station Kuchyňa – Nový Dvor and during 1971 – 2000 in case of the Malacky.



# Calculation of the Actual Evapotranspiration

**Computation of the evapotranspiration in case of the long-term course – minimally 30 years:**

soil humidity at the beginning of time interval [cm]

at the end

$$\overline{W} = \frac{W_1 + W_2}{2}$$

$$\mathbf{E = E_0 \frac{\overline{W}}{W_0}}$$

average soil humidity [cm]

critical humidity [cm]

potential evapotranspiration [cm]

precipitation [cm]

$$W_2 = \frac{P - W_1\left[\frac{E_0}{2W_0} + \frac{P}{2W_k}\sqrt{\alpha^2\left[1-\left(1-\frac{E_0}{P}\right)^2\right]+\left(1-\frac{E_0}{P}\right)^2} - 1\right]}{\frac{E_0}{2W_0} + \frac{P}{2W_k}\sqrt{\alpha^2\left[1-\left(1-\frac{E_0}{P}\right)^2\right]+\left(1-\frac{E_0}{P}\right)^2} + 1} \qquad 0 < \overline{W} < W_0$$

$$W_2 = \frac{P - E_0 + W_1\left[1 - \frac{P}{2W_k}\sqrt{\alpha^2\left[1-\left(1-\frac{E_0}{P}\right)^2\right]+\left(1-\frac{E_0}{P}\right)^2}\right]}{1 + \frac{P}{2W_k}\sqrt{\alpha^2\left[1-\left(1-\frac{E_0}{P}\right)^2\right]+\left(1-\frac{E_0}{P}\right)^2}} \qquad \overline{W} \geq W_0$$

$$P \geq E_0$$

the biggest value $W_0$ during the year [cm]

proportionality coefficient, which depend on the precipitation intensity

# Calculation of the Actual Evapotranspiration

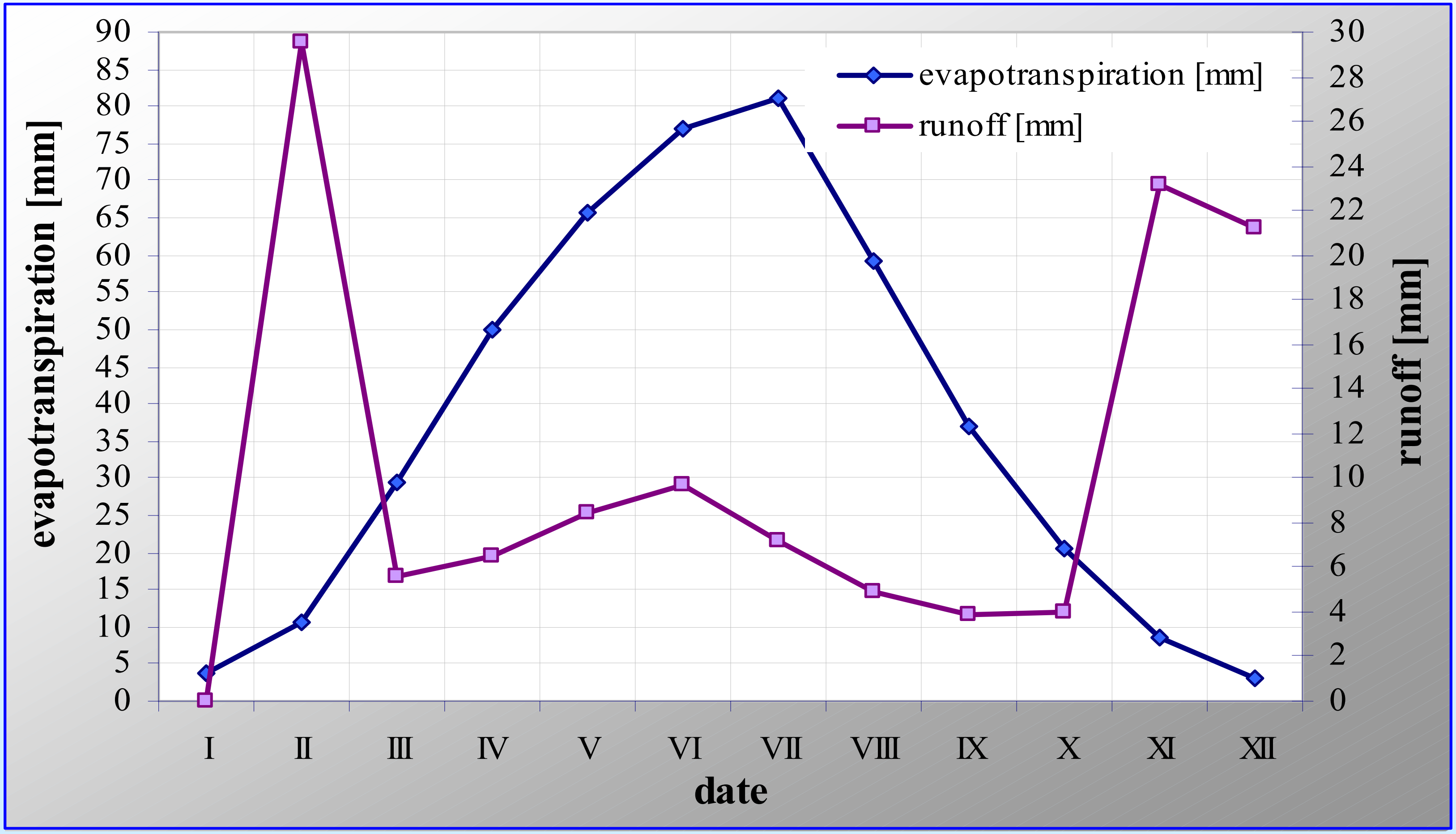
$$\left.\begin{array}{ll} W_2 = \dfrac{P - W_1\left(\dfrac{E_0}{2W_0} + \dfrac{\alpha P}{2W_k} - 1\right)}{\left(\dfrac{E_0}{2W_0} + \dfrac{\alpha P}{2W_k} + 1\right)} & 0 < \overline{W} < W_0 \\[3em] W_2 = \dfrac{P - E_0 - W_1\left(\dfrac{\alpha P}{2W_k} - 1\right)}{\dfrac{\alpha P}{2W_k} + 1} & \overline{W} \geq W_0 \end{array}\right\} \quad P < E_0$$

Average annual total of actual evapotranspiration during 1961 – 1990 for Meteorological Station Kuchyňa – Nový Dvor: 652 mm

Average annual total of actual evapotranspiration during 1971 – 2000 for Meteorological Station Malacky: 446 mm

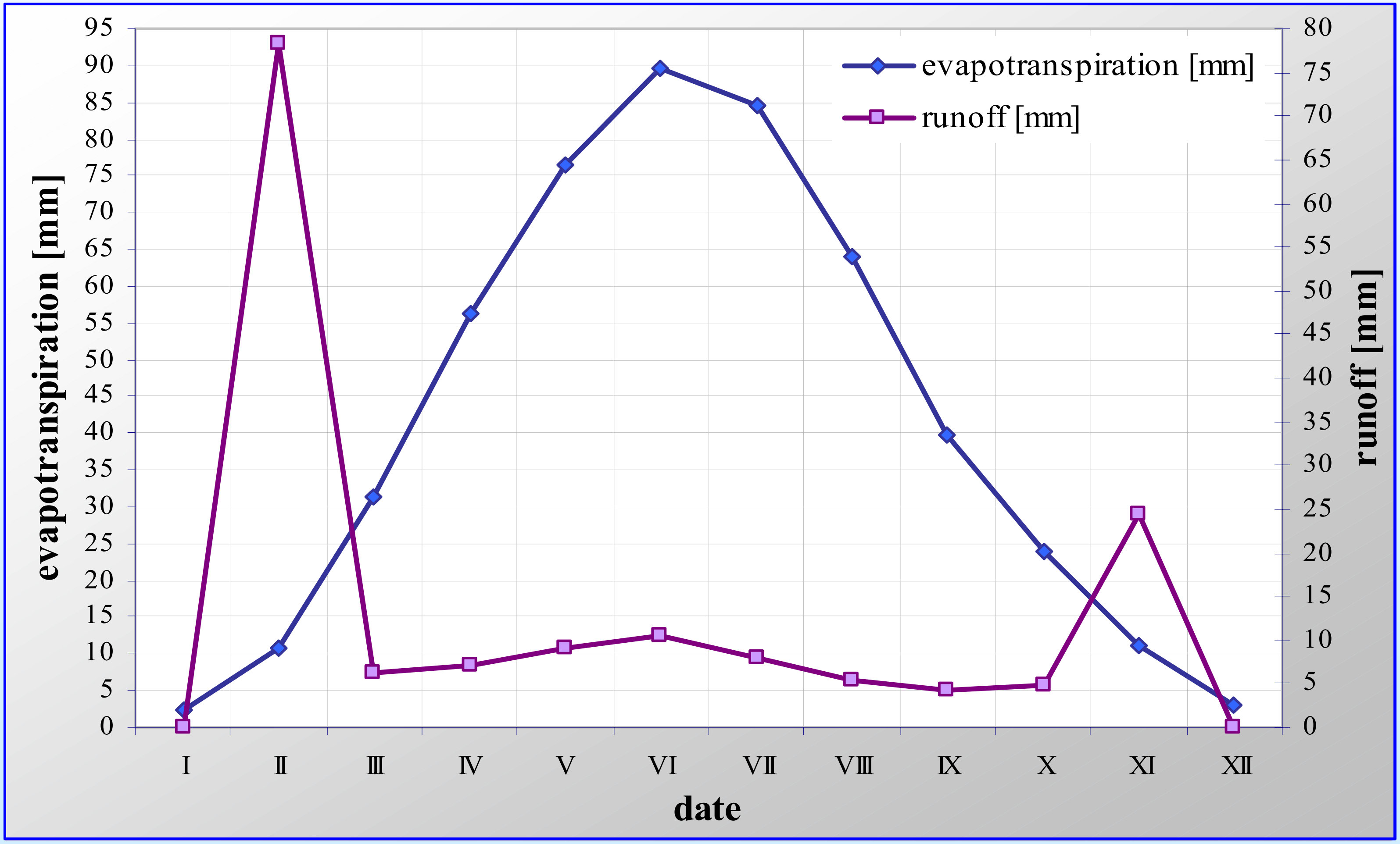
# Calculation of the Actual Evapotranspiration

Average monthly totals of the evapotranspiration and monthy runoff values during 1971 – 2000 in case of the Meteorological Station Malacky.



# Calculation of the Actual Evapotranspiration

Average monthly totals of the evapotranspiration and monthy runoff values during 1961 – 1990 in case of the Meteorological Station Kuchyňa – Nový Dvor.



# Restoration measurement

**In the past it was supposed increasing of the agricultural land acreage. From this reason it was realised drainage of the wet areas. At the present, when the using of the surrounding areas is not very interesting for the agriculture, the question of restoration measures is very prefered.**

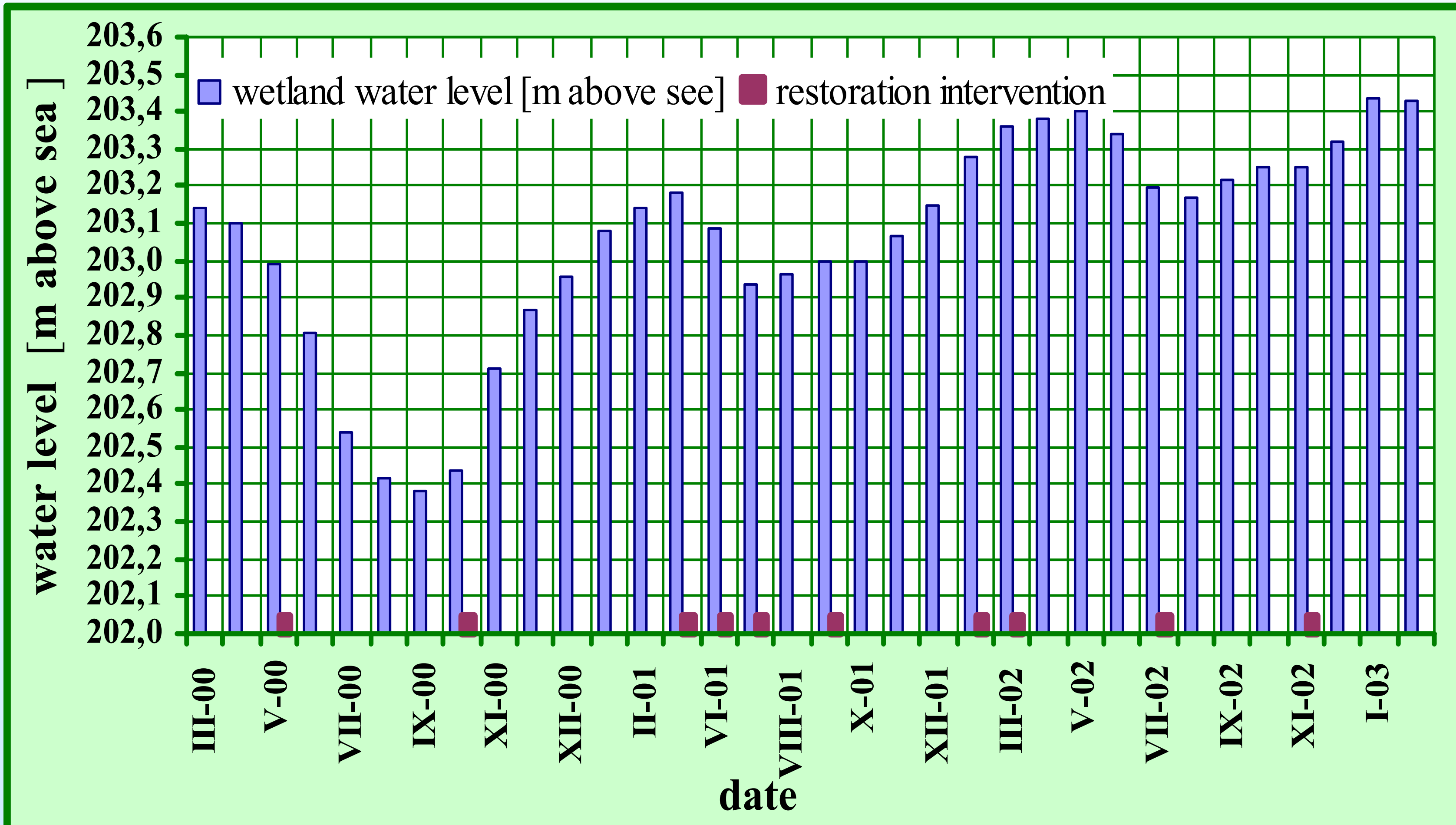
**During 2000 – 2001 it was built 12 barrages through the drainage ditches.**

**Increase of the water level: 56 cm ⟶ compensation of water level decrease in 1980-s (it was caused by digging of drainage ditches)**

## Positive influence on the water regime in short period:

# Restoration measurement

**Changes of the water level regime in dependence of restoration intervention** in **NNR Zelienka:**



# Ecological - protection status of the locality Zelienka

**Decrease of the groundwater level by influence of area drainage brought adverse changes to the total regime: decrease of evaporation and climate humidity, change in runoff proportions, sharp change of hydroecological conditions.**

**In this locality remain only a few fragmentary developed wetland biotops.**

**It arised a strong movement to the more xerophile phytocenoses: The *Carex elata* was substituted by phytocenose *Molinio – Arrhenatheretea.***

**Before drainage of the locality (second mid of 1970-s):**

- **phytocenose *Peucedano – Caritum lasiocarpae and Caricetum elatae.***
- **relict, especially important species of Zahorie flora – *Rhynchospora alba. Drosera rotundifolia, Viola palustris, Comarum palustre, Pedicularis palustris, Menyathes trifoliata, Rhynchospora alba.***
- ***Association Spaghno warnstorfiani (Caricetum davallianae) suffered the most.***

# Ecological - protection status of the locality Zelienka

**It retained fragments of *Caricetum elatae* with interesting *Cirsium palustris* and tall sedges, especially *Carex elata, Caricetum elatae*.**

**A liquidation of drainage ditch benefits to development of the fen alder woods *Alnetea glutinosae.***

**Wood layer – *Alnus glitinosa, Batula pubescens, particularly oak trees and more kinds of Salix***

**Brush layer - *Fragula alnus, Sorbus aucuparia, Viburnum opulus***

**Herb layer – *Iris pseudacorus, Hottonia palustris, Cardamine, Scirpus sylavticus, Saltha palustris, Dryopteris cristata, Thelipteris thelipteriodes, Thysselinum palustre***


THANK YOU
FOR YOUR ATENTION