APPENDIX 6

PROFESSIONAL ACHIEVEMENT SUMMARY

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Wrocław, 25.04.2013

1. Scientific degrees, diplomas, professional qualifications

- **Master of Science**, degree received in 1989 at the Department of Land Reclamation and Irrigation of the University of Agricultural (presently Faculty of Environmental Engineering and Geodesy of the University of Environmental and Life Sciences) in Wrocław. The master's thesis *Concepts of fishpond restoration in the Pruszowice Agricultural Experiment Station* was a case study of an inactive fishpond and assessment of its restoration possibility. In my work, I proposed three concepts of the fishpond restoration after hydrological, ecological and economic analyses.
- **Diploma** (1994) of Postgraduate Study „Water and Environment" organized within the TEMPUS Programme at the Agricultural Academy in Wrocław. The study was concerned with an interdisciplinary approach to the eco-morphological assessment of river ecosystems integrating hydrology and biology.
- **Doctor of Agricultural Science,** degree received in 1999 at the Department of Land Reclamation and Irrigation of the Agricultural Academy in Wrocław (presently Faculty of Environmental Engineering and Geodesy of the Wrocław University of Environmental and Life Sciences). The doctoral dissertation *Dynamics of surface water and groundwater resources in the area of the Klodzko Valley* was written under the supervision of Professor Włodzimierz Czamara Ph.D., Eng.
- **Qualifications** for elaboration of hydrological documentation (Nr 24/2004) issued by the Minister for the Environment, 2004.
- **Postgraduate Study Diploma** (2010) of the Wrocław University of Technology in the field of „Research Project Management and Commercialization of Research Results". Operational Programme for Human Capital, Priority 4 "Tertiary Education and Science", Measure 4.2. Development of R&D System Staff Qualifications and Improving the Awareness of the Role of the Science in Economic Growth, co-financed by the European Union.

2. History of employment in research institutions

- September 1989 - April 1990: internship in the Institute of Agricultural and Forested Land Reclamation at the Department of Drainage, Agricultural Academy in Wrocław.
- November 1994 – November 1999: doctoral programme in environmental management at the Department of Land Reclamation and Irrigation of the Agricultural Academy (presently Faculty of Environmental Engineering and Geodesy of the University of Environmental and Life Sciences) in Wrocław.
- January 2000 - present: Institute of Meteorology and Water Management Branch Wrocław: a senior specialist in the Department of Hydrology (until November 2000); December 2000 appointed adjunct acting as: October 2001-February 2010: the head of the hydrological methodology and research team; March 2010-March 2011: the deputy manager of the

Flood and Drought Modeling Center; April 2012-present: manager of the Flood and Drought Modeling Center.

3. Description of Accomplishments pursuant to the Article 16 of the Act 2 of 14 March 2004 on Academic Degrees and Titles and on Titles in Art (Journal of Laws No. 65, Item 595 as amended)

Scientific achievement resulting from above Legal Act is dissertation:
Tokarczyk T., 2010. Niżówka jako wskaźnik suszy hydrologicznej (*Low flow as indicator of hydrological drought*). Wyd. IMGW, S. Monografie IMGW, ISBN 978-83-61102-34-2, s. 164. Warszawa.

Drought estimate requires multi-criteria approach that includes meteorological, hydrological and hydrogeological elements as well as social aspects. Complexity of the phenomenon results also from the fact that although drought is a common phenomenon of physical and social dimensions, there is no universal definition of drought. However, despite different approaches to drought estimation and definition, all researchers agree on the process description, i.e. sequence of distinct phases: meteorological drought (caused by the shortage or absence of precipitation and high air temperature), agricultural drought (causative agents include evaporation, water deficit in the aeration zone), hydrological drought (decreased river flows, drying watercourses and wells), economic drought (economic and environmental losses). Hydrological drought is the final phase in drought formation process. It can be, therefore, concluded that this phase represents the completion of the process in terms of hydrometeorology and hydrogeology.

The necessity to define precisely hydrological drought, to classify the phenomenon according to criteria fit for a given area and to characterize it using numerical parameters results, therefore, from the practical considerations. Solution to this demand may be hydrological drought index resulting from the analysis of catchment desiccation and derived from the available meteorological and hydrological data provided by the continuous observations of the : Institute of Meteorology and Water Management measurement network.

The research hypothesis proposed in my habilitation dissertation stating that low flow is an indicator of hydrological drought imposes a solution that, on one hand, includes physical characteristics of the phenomenon, and, on the other hand, takes into account its randomness. The model presented in the dissertation allowed to develop a comprehensive statistical-deterministic hybrid approach in the description of low flow formation process. Such approach includes both causality (deterministic model reflecting dynamics of groundwater resources depletion process during low flow periods) and randomness (probabilistic model) of the low flow phenomenon.

All arguments address the following general and specific topics:

- concept of drought, definition of drought, definition of hydrological drought,
- low flows as hydrological drought characteristic including criteria for determining threshold value of low flow, methods of separation of low flows as independent events and probabilistic low flow model,
- criteria for separation of droughts and their classification within the low flow set,
- development of hydrological drought indicator,
- groundwater resources depletion process including deterministic low flow model,
- selection of hybrid models of hydrological drought and their validity tests,
- synchronicity of climatic water balance and low flows, and hydrological droughts,
- drought estimates in ungauged catchments.

In my work I used two models: the deterministic model Recession Curve Analysis (RCA) based on hydrograph recession limbs selected from a multiyear period that was used for the estimate of river alimentation from groundwater, the estimate of groundwater depletion rate including runoff phases, and the probabilistic model NIŻÓWKA for the statistical analysis of flow time series. The selection of criterion for threshold flow and adapting the method of independent event separation are the key steps in statistical analysis. Selection of the criterion and the value of low flow threshold are determined not only by climate conditions and data availability but also by river hydrological regime. In case of rives characterized by a visible seasonality it is advised to determine threshold flow values independently for each season. Different approaches to determination of threshold flow value are also aimed to separate daily flow anomalies. Of the many methods of independent events separation widely discussed in the literature, only the method used in my work, the **method of consecutive minima series** includes deficit volume in low flow periods and conditions of low flow onset and cessation.

The analysis of probabilistic model results was the basis for **determining hydrological drought indicator** as a random extreme event of importance for water management.

The hydrological drought indicator (*WSH*) I introduced is the ratio of deficit volume and low flow duration which characterizes the intensity of the phenomenon. I also introduced the concept of the **plausible extreme hydrological drought** described by the hydrological drought indicator which is the ratio of deficit volume of low flow of non-exceedance probability value of 95% and duration of low flow of non-exceedance probability value of 95% ($WSH_{95} = D_{95} \times T_{95}$). Plausible extreme hydrological drought is a drought which, from the point of view of process and sequence of events, is real and its occurrences have been confirmed in the analyzed catchments – once or twice in the analyzed 40-year period of 1966-2005. Further, I carried out a classification of low flows using the method of multivariate cartogram presenting two variables: duration and deficit volume during low water event. I divided the set into five classes, i.e. (i) short term low flow, (ii) long-term low flow, (iii) moderate hydrological drought, (iv) deep hydrological drought, (v) extreme hydrological drought. The classification, therefore, allowed to separate hydrological droughts of different intensity resulting from deficit volume and duration from the set of low flow events. It is a scalar and vectorial estimate of hydrological drought with the reference to a single cross section. In the spatial estimate, on the other hand, vector indicates selected hydrological drought indices at several cross sections reflecting processes occurring within a catchment.

For the purpose of the estimation of characteristics of **hydrological droughts in ungauged catchments** in hydrological aspects, hybrid models were developed. These models can be used for the assessment of the hydrological drought vulnerability of ungauged catchments. Selected parameters of probabilistic and deterministic models were the basis for the development of three hybrid models:

- hydrological drought indicator (*WSH*) (Chapter 7.4) based on catchment drought vulnerability indicator (ΔQ_B) (Chapter 7.5);
- relative flow deficit (D_w) (Chapter 7.4) based on recession coefficient (α) (Chapter 7.5);
- probability of above zero deficit volume ($ppD > 0$) (Chapter 7.4) based on retention of dynamic groundwater resources in the active exchange zone (R_{SAWDWP}) (Chapter 7.5).

The causes of uncertainty in hydrological processes modeling are: model inadequacy for the described process, measurement uncertainty as well as assumptions and hypotheses regarding the insufficiently recognized causal relationships. This results from the current state of knowledge and simplifications in the construction of mathematical models. To validate the proposed methodology, the study of the basin of Nysa Kłodzka River was carried out. The research area included the Nysa Kłodzka River from its sources to the Bardo gauging station and the basin was divided into 11 partial catchments.

The relationship of hydrological drought indicator determined for the value of plausible extreme drought and groundwater alimentation potential $WSH = f(\Delta Q_B)$ is the basis of determination of the volume of the potential alimentation from groundwater resources which results in the occurrence of plausible extreme hydrological drought.

The relation between relative flow deficit and recession curve coefficient $D_w = f(\alpha)$ is the basis for the estimation of basin low flow and hydrological drought vulnerability.

The presented relation between the probability of above zero deficit volume and retention of dynamic groundwater resources in the active exchange zone $ppD > 0 = f(R_{SAWDWP})$ describes catchment conditions at which low flow and hydrological drought occur.

The quality of the developed models was estimated using determination coefficient whose value reflects strong causal relationship. Validation of the developed models involves, therefore, checking if they are consistent with the assumptions, i.e. if low flows and droughts can be described by both deterministic and probabilistic models. Independent variables used in the models represent different aspects of causes and are consistent with the requirements of parameter interpretation and analysis. Verification of the parameters, therefore, should answer the question if the model fulfils its intended purpose, if it is a useful model since the knowledge of the subject matters and consistency with the proposed assumptions are the conditions of correct model construction.

Statistical verification included estimation of model quality using the following criteria:

- consistency of observational data with model predictions,
- estimate of model extrapolation potential.

Consistency of observational data with the model was assessed using:

- residual variance,

- residual standard deviation,
- residual variability coefficient,
- consistency coefficient,
- determination coefficient,
- correlation coefficient.

The purpose of the **estimate of model extrapolation potential** is to determine the value of dependent variable on the basis of selected independent (explanatory) variables. Model extrapolation potential can be tested by calculating deviations while removing one by one subsequent observations. Mean prediction error is a mean square error of prediction equations for given $n-1$ observations. Lower error values indicate higher predictive capacity of the model. The value of groundwater alimentation is represented by base flow recession curve. Base flow value is different for each year and is determined by the catchment retention level and geological structure including river base level at the location of river gauging station. In dry years, base flow is very low. It can be assumed that such conditions of groundwater alimentation potential exist that plausible extreme hydrological drought occurs. This dependency is strictly regional characteristic. The exponential dependence of the plausible hydrological drought on groundwaters alimentation potential $WSH_{95} = 938{,}31e^{0{,}1531\Delta Q_B}$ was reduced to linear form by taking logarithms: $WSH_{95} = 6{,}8441 + 0{,}1531\,\Delta Q_B$. This operation allowed to determine the above described statistical characteristics. The estimate of model extrapolation potential made it possible to improve the model in two cases, i.e. for Żelazno gauge data set and Tłumaczów gauge data set.

Depletion rate of groundwater resources according to hybrid model expressed as $D_w = 24{,}19\alpha^{3{,}3295}$ represents recession coefficient. Its variability is determined by catchment conditions. It gives the information about the time needed for stabilization of flows at the base flow level. It can be, therefore, assumed that depletion rate is causally related to deficit volume during river low flow periods. Deficit volume expressed as a relative value enables its comparisons for different catchments. Parameters of quality estimates of the tested hybrid models show good agreement between observation data and parameters predicted by the model.

The assessment of model extrapolation potential showed that mean prediction errors allow the use of the developed models as predictive models. The condition for application of these models is a total hydrological similarity of catchments. The developed models are regional models and can be used only for catchments with similar physiographic and climatic conditions.

For the purpose of the estimate of hydrological drought characteristics in ungauged catchments in its hydrological aspects, the base flow dependence on catchment climate factors was examined. The analysis of selected model parameters allowed to find the dependence of base flow (Q_B) values of each year in a multiyear period on summer season mean precipitation total in catchment. Synchronicity of climatic water balance and occurrences of low flows and droughts, demonstrated on the basis of relationship between standardized indicator of hydrological drought ($WSH_z = D \times T / D_{95} \times T_{95}$) and standardized climatic water balance (KBW_s), was confirmed by the calculated values of correlation coefficient.

Hybrid models were also developed for the Prosna River in order to test if the developed methodology for the assessment of hydrological drought can be applied to lowland catchments. Quality of the models was assessed using determination coefficient. Its value demonstrates strong relationship. The purpose of these models, therefore, is the same as it is in the case of the Nysa Kłodzka River catchment. Their applicability is limited to catchments characterized by total hydrological similarity.

The findings of the study opened a possibility to formulate directions of further study of hydrological drought:

- study of hydrometeorological processes leading to development of droughts including drought occurrences in winter season which are particularly important for water quality assessment,
- study of onset and end dates of seasonal phenomena on a regional scale,
- integration of atmospheric circulation types with low flows and hydrological droughts,
- monitoring system for the real-time drought forecasting,
- impact of climate variability, changes in spatial management and human activity on frequency of low flow and hydrological drought occurrences.

Given all the above mentioned postulates (proposals), the developed method of hydrological drought assessment should be applied at all gauging stations for which hydrological prognoses are prepared.

4 Essentials scientific accomplishments

Formation of my personality as a scientific researcher commenced at the beginning of the doctoral studies where I actively participated in team research conducted at the Institute of Environmental Engineering in the Department of Hydrology and Water Management of the then Agricultural Academy in Wrocław. Since the 1960's the Institute has been implementing the principle of a strict relation between theoretical and practical issues of hydrology (Professor Julian Wołoszyn Ph.D., Eng.), water management (Professor Adam Szpindor Ph.D., Eng.) and hydraulic engineering (Professor Zbigniew Dziewoński Ph.D., Eng.) which reflected the current trends in scientific development striving to apply the latest knowledge in the engineering practice.

My annual participation since 1996 in the School "Current hydrological issues" under the direction of Professor Maria Ozga-Zielińska Ph.D., Eng., has had considerable impact on my research interests. The presented latest accomplishments in the field of hydrology and references to other scientific disciplines directed me to find solutions in hydrology using methods and theories applied in mathematics, engineering and economics.

The principal research directions in which I engaged in the period of 2000-2012 resulting from both the development of my personal interests and participation in scientific research conducted at the Institute of Meteorology and Water Management – National Research Institute (IMGW-PIB) include three main branches of hydrology:

a. Low flow and hydrological drought – methodical approach and application in:

- three-parameter description of low flow (duration, deficit volume, minimum low flow discharge),
- frequency of low flow occurrences,
- low flow seasonality,
- probability of non-exceedance of deficit volume and duration thresholds in one-dimensional and two-dimensional perspectives,
- spatial and temporal variability of low flow intensity,
- low flow classification,
- index based assessment of drought hazard,
- drought forecasting.

[publications: Appx. 3: B.3, B.4, B.9, B.17, B.19, B.23, B.24, B.25, B.29, B.30; Appx. 3: 5b.2, 5b.10, 5b.11, 5b.12, 5b.13, 5b.14, Appx. 5: item: 7, 12]

b. Quantitative assessment of water resources:

- small retention,
- groundwater resources estimation methodology,
- methodology for water resources estimation in different alimentation conditions,
- methodology of water resources estimation in diverse land use catchments,
- methodology for determination of ecological flow,
- water management balance.

[publications: Appx. 3: B.6, B.8, B.10, B.11, B.12, B.15, B.18, B.20, B.21, B.22, B.27, 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8, 4.10, 4.12, 4.13, 4.17; 5b.1, 5b.2, 5b.3, 5b.4, 5b.5, 5b.6, 5.b7, 5b.8, 5b.9, Appx. 5: item:1, 2, 3, 4, 11, 13, 14, 16]

c. Flood hazard assessment in the context of changing climate:

- estimates of discharge of a given exceedance probability value,
- flood hazard maps,
- flood risk assessment.

[publications: Appx. 3: A.2, B.1, B.2, B.13, B.14, B.16, B.28; 4.9, 4.11, 416, 4.18, Appx. 5: item: 5, 7, 8, 9, 10, 15, 17].

4.1 Low flow and hydrological drought – spatio-temporal methodological and application approach

The profile of my interests in this field was greatly influenced by my participation and close cooperation with the members of the international Low Flow Group in the Project FRIEND directed by Professor Elżbieta Kupczyk Ph.D., Eng. in 1995. Initially, the consortium of European experts, acting within the Programme Flow Regimes from International Experimental and Network Data Northern and Western Europe – FRIEND under the auspices of UNESCO, focused on promotion and support of regional research on low flow and drought. In 2002, the group changed its name to LOW FLOW & DROUGHT after it had broadened its interests to hydrological drought and particularly to the basic processes of drought formation, definition, extreme values, temporal and spatial variability and development of operational hydrological drought forecasting.

My research focused primarily on the low flow formation, method of low flow separation using daily flow series, low flow parameter based description and analyses of low flow frequency and spatial variability. First results were presented in my doctoral dissertation *Dynamics of surface water and groundwater resources in the area of the Klodzko Valley* where I carried out a preliminary estimate of low flow focusing on streamflow dynamics. Separation of low flows in a series of hydrological elements is crucial for a rational water management. Since the conventional methods of low flow estimates based on specific flow values are unreliable, because minimum flow values over a given fixed interval cannot be the basis for determining deficit volume, and their measurements are characterized by a large error, they are insufficient for water management. Consequently, I focused on low flow occurrences: their duration and seasonality. Research results showed that variability of low flow occurrences depends not only on climate conditions but also on the geological structure of catchment area. Dynamics of catchment water alimentation from aquifers is described by the recession curve which reflects the integrated impact of factors determining catchment runoff in dry periods. The conducted estimate of flows in the full spectrum of their variability allowed to separate specific alimentation phases, i.e. alimentation from surface, subsurface and underground, and to determine duration of each phase which is a valuable information about catchment retention resources and dynamics of their depletion.

The concept I had developed and the methodology adapted in my doctoral dissertation were used to estimate water resources in the basin of the Upper and Lower Odra River in drought conditions [Appx. 3: B.6, 5b.2]. The work was awarded by the Minister for the Environment in 2003.
Close cooperation with the Department of Mathematics of the Wrocław University of Environmental and Life Sciences in the field of research concepts and methodology for description of low flow formation process resulted in the development of the new research tool, i.e. "NIŻÓWKA" software. The initiative resulted from the in-depth study of the international and Polish literature on the subject which clearly indicated the need of research in this direction. The work provided the basis for low flow estimates using methods that account for randomness. My habilitation dissertation *Low flow as hydrological drought indicator* was the result of this work [Appx. 3: B.17, B.19].

The beginning of the 21st century was characterized by high frequency of drought occurrences in Poland. The most severe droughts characterized by high intensity and long duration took place in 2003 and 2006. The IPCC report on climate change predicts the increase of drought frequency and intensity. This creates a stronger need for development of tools for aiding effective decision making process and for drought mitigation. Accurate and timely information concerning drought is an important element of national water management and hydrometeorological protection systems. The experience gained through scientific research resulted in the development of the concept of *Operational hydrological drought forecasting* and its implementation i.e. Prognostic-Operational System of Drought Characteristics **POSUCH@** (**P**rognostyczno-**O**peracyjny **S**ystem **U**dostępniania **CHa**rakterystyk Suszy) available on in the Internet. The service was created within the activities of the project *Climate change impact on the environment, economy and society,* acronym KLIMAT (POIG.01.03.01-14-011/08). It is a comprehensive, multi-task system of drought forecast and drought estimate to be used as an operating system. Index based drought description is the basis for development of tools for drought monitoring, forecasting and water management while taking into account drought development, particularly meteorological and hydrological phases. The indices used allow to relate current conditions to climate background and are standardized, dimensionless intensity estimates that can be referenced against different regions and periods, enable detection of each drought development phase and presentation of drought temporal and spatial variability. Drought hazard forecast is based on prognosis of humidity and meteorological conditions. The prognoses are produced using deterministic method and numerical weather model (short term forecast) and statistical method (long-range prognosis) based on transition probability matrices corresponding to different humidity conditions [Appx. 3: B.24, B.25, B.26, B.30, 5a.1, 5b.11, 5b.12, 5b.13, 5b.14].

4.2 Quantative estimate of water resources in diverse land use catchments

This area of my research activities is directed toward the support of effective water management on a regional scale, i.e. regional water management in the upper and lower Odra River catchment. Current water policy imposes this approach as the most effective strategy for sustainable development which puts the emphasis on the local (regional) conditions. In 2006-2007, pursuing this field of research within international framework, I coordinated the task: *Assessment of hydrological characteristics of the Polish territory during different climatic conditions* as a part of the project Hydrological Cycle of the CADSES Regions HYDROCARE [Appx. 3: 4.10, 5b.9]. The research aimed to assess water resources in five selected catchments characterized by diverse land use and hydrological regime (dammed catchment, agricultural catchment, fluvio-lacustrine system catchment, quasi-natural catchment, and anthropogenically modified catchment) in average, dry and wet periods. **The results of this work were contributed to the European database of pilot catchments to be used for development of methodological standards in water resources balancing.**

Consequently, in 2007, I was appointed responsible for the task of development and selection of methods for water resources estimates for rives of diverse character and river management level [Appx. 3: 5b.8, 5b.9]. The work focused on water resources estimate according to the adapted definition i.e. **water resources consist of river runoff which is the effect of the studied phenomenon at the scale of several decades.** The following division of resources was applied: (i) basic – represented by mean flow, (ii) in water shortage periods – represented by low flows, and (iii) in periods of excess water – represented by maximum flows. Such division of water resources is used as hydrological information for the needs of planning, construction of hydrotechnical objects and water management. The project results included the development of methodological basis for the assessment of catchment retention capacity, assessment of proportion of dynamic groundwater resources in total runoff and assessment of water resources in different hydrological conditions. Research results are documented in publications [Appx. 3: B.20, B.27, 4.1, 4.6, 4.7, 4.8, 4.13, 4.14] and *Methods of estimating water resources in catchments of rivers of different type and management level* [Appx. 3: B.27].

4 3. Flood hazard assessment in the conditions of changing climate

Characteristic feature of modern science and scientific research is the necessity to manage extensive and comprehensive research tasks corresponding to multidisciplinary topics carried out by multidisciplinary teams. I have had the happy opportunity to participate in works of such teams since the beginning of my postgraduate studies. This research activity was concerned with applied hydrology oriented toward hydrological information processing for the needs of water management planning and development.

After the catastrophic flood in the basins of Odra and Wisła rivers in 1997, my applied science work, in 2003-2004, focused on problems of flood hazard and flood protection. Its principal goal was the cooperation in development and implementation of PrzepływyMax2011 software, a tool for the identification of maximum annual flow frequency as the input data for delineation of flood zones of controlled rivers for flows of a given exceedance probability.

Following the 1997 great flood, in Poland, but more precisely in the area of the upper and central Odra River basin and the upper Wisła River basin, methodological fundaments of standardized assessment of flood hazard using hydrodynamic model of river runoff based particularly on the one-dimensional HEC-RAS Hydraulic Model, have been developed.

Each new high water occurrence gives an opportunity to analyze and diagnose the magnitude of the event. It is important for the improvement of flood protection in terms of preparedness, prevention, reaction and recovery. Consequently, after the flood in May and June 2010 in the Odra River basin, and in August 2010 in the Nysa Łużycka catchment, the Institute of Meteorology and Water Management – National Research Institute published the monograph *The Odra River Basin Flood of 2010* which I co-authored [Appx. 3: 4.24].

Presently, as the manager of the Flood and Drought Modeling Center, I have focused on the development of flood hazard maps delineating flood plains for flows of given exceedance probability and other flood scenarios such as levee failure. Determining discharge values of a given exceedance probability and their corresponding high flow hydrographs, the so called hypothetical flood waves at gauging station, was preceded by the search of a uniform methodology for identification of flows of given exceedance probability, the result of which is the implementation of PrzepływyMAx2011 software in every Hydrological Forecast Bureau in each branch of the Institute of Meteorology and Water Management – National Research Institute. I presented the results of this work at the Science and Technology Conference *Issues in calculating extreme flows in controlled and ungauged catchments* organized by the SHP (Warsaw, 2012).

5. Other scientific accomplishments

My other scientific accomplishments are closely related to my function as the head of research teams established to work on specific hydrological issues in the IMGW-PIB. My co-authorship in the presented publications, above all, included team organization,

development of research concept and methodology, analysis of the results, preparation of conclusions and text editing.
The cooperation within the international Low Flow Group allowed me to direct the methodological work toward a uniform treatment of low flows and hydrological droughts which bears significant practical value. This research resulted in an attempt to assess low flow occurrence hazard in catchments of diverse characteristics. The results were published by IAHS Press, Red Book Series in Hydrological Sciences Journal [Appx. 3: B.19] and in Polish journals [Appx. 3: 4.15].

Realizing the need of introduction of measures in order to conduct comparative analysis of both magnitude and intensity of low flow and hydrological drought events for rivers of different hydrological regimes located in different climate regions, I decided that index based assessment fulfills these requirements since indices provide numerical information on properties of a given phenomenon. Indicator as an absolute value illustrates the magnitude of the studied phenomenon (instantaneous value, specific value) while indicator as a relative value (relation of two or more values) reflects the structure and dynamics of the phenomenon. Index based description of phenomenon makes it possible to describe its intensity, severity and to compare its properties in different geographic and climate conditions. This approach was successfully validated by research carried out within the statutory activities of the Institute of Meteorology and Water Management-National Research Institute in 2008. I headed the task of *Assessment of drought occurrence risk in Poland* which consisted of index based assessment of low flows and the risk of their occurrences [Appx. 3: 5b.8].

The results of this research were presented in conferences and at the General Assembly of the European Geosciences Union. Furthermore, they were the basis for initiating, in 2011, cooperation with Professor Janusz Kindler on the development of regional project *Integrated Drought Management in Central and Eastern Europe* within the Integrated Management System programme under the auspices of the World Meteorological Organization (WMO) and the Global Water Partnership (GWP) which is currently carried out [Appx. 3: 5b.14].

A considerable scale of the Nysa Łużycka river regime transformation has become a serious problem in terms of environmental hazards. In this context, research directed by me includes thee aspects of the problem: ecological, social and economic. This approach is particularly important in case of transboundary catchments where legal regulations and water management policy require international agreements and specification of clear rules of sharing available surface water resources must be consistent with bilateral agreements and the Water Framework Directive. The results of this project include detailed analyses of possible allotment of water resources which take into consideration three schemes of using the available resources, i.e. each country uses the available resources (i) according to their demand, (ii) in equal quantities, (iii) according to common criteria of sharing water resources accounting for user needs and ability to meet those needs in the conditions of limited water resources. The results were documented in publications [Appx. 3: B.5, Appx. 5, item 1]. In the context of this issue, detailed application problems oriented toward increasing effective and rational use of water resources were also studied with the following results:

- Alternative concepts of reclamation of open pit of the Berzdorf opencast lignite mine oriented toward transforming it into multifunctional retention reservoir. Analysis of three schemes of water abstraction from the Nysa Łużycka River and water transfer from the Nysa Łużycka River to the Spree River catchment, taking into account preserving the adequate volume of available surface water resources and losses of Polish hydropower plants was carried out. At the same time, the impact of water withdrawal from the Nysa Łużycka River on water quality, biota in river dependent habitats was analyzed [Appx. 5: item 2].

- Development of statistical water balance based on hydrological data from 1998 and the number of Polish and German water users in 1998 as well as perspective water balance for 2005. Determination of the natural and actual flows in the longitudinal river profile and ecological flow was the basis for determining the volume of water available for non-returnable withdrawal at gauging stations. The work also includes assessment of hydrological conditions of the Nysa Łużycka River in different scenarios of water withdrawal and alternative solutions regarding the flooding of Berzdorf open pit and water transfer to the Spree River catchment and losses of Polish hydropower plants [Appx. 5: item 3].

This research was the basis of the implemented hydrological-meteorological monitoring as well as biomonitoring of the Nysa Łużycka River oriented toward detection of the impact of water withdrawal from the river on the environment. The monitoring has been continued to the present and its results are presented in annual reports.

Additionally, in 2000-2004, I organized and supervised the work aimed at supporting the statutory activities of the State Hydrological-Meteorological Service in the field of quantative prognoses of changes of water resources as the result of the planned economic activities in the Odra River basin. The research results were presented in the publication *The Widawa River Monograph* [Appx. 3: B.21, 5b.3].

Cooperation in many national and international research teams allowed me to put the issues of flood protection in the scientific, environmental, economic and social contexts. The most significant projects completed is this area are:

- 2002-2003 – European Flood Forecasting System EFFS-NAS 1, project realized within the Fifth EU Framework Programme,
- 2002-2006 - Real-Time Decision Support System Integrating Hydrological, Meteorological and Remote Sensing Technologies FLOODRELIEF, project realized within the Fifth EU Framework Programme
- 2008 – development project *Geo-ecological condtions of the Stolowe Mountains National Park,* NCBiR No. 09-0029-04/2008, Wrocław University of Environmental and Life Sciences, Institute of Meteorology and Water Management Wrocław Branch.
- since 2010 – project the Information System for Protection against Natural and Man-made Hazards ISOK realized within the Operational Programme - Innovative Economy and co-financed by The European Regional Development Fund.

The research effects of my participation in these activities included the development of MIKE 11simulation model for the Kaczawa River catchment. Mean precipitation values for partial catchments were determined using data provided by ground weather stations and meteorological radar. An attempt to integrate meteorological and hydrological models was made. In case of the Czerwona Woda River in the Stołowe Mountains National Park, precipitation-runoff model was developed using the HEC-HMS platform and scenarios of impact of land use changes and climate condition changes on catchment runoff were created. The research findings were presented in national and international conferences and are documented in publication [Appx. 3: B.17].

In 2011 and 2012, I supervised the team realizing the statutory tasks of the Institute of Meteorology and Water Management-National Research Institute involving the analysis of dependable and controlled discharges of dams in retention reservoirs selected by the Regional Water Management Authority (RZGW). After the 2010 flood in the basins of the upper Odra River and the upper Wisła River, an urgent necessity to develop new instructions based on current methods of engineering hydrology, which take into account different scenarios of retention reservoir uses has emerged.

6. Summary of scientific achievements

Taking into account the entire body of my scientific-research work, my most important achievements, which contain an innovative approach to studied phenomena and processes are:

- estimate of low flows using deterministic and probabilistic approach – recession curve characterizes the dynamics of water resources depletion, while probability of non-exceedance of deficit volume and duration characterize randomness of the phenomenon;
- application of classification methods used in cartography for the analysis of hydrological phenomena - multivariate cartogram method;
- classification of low flows and hydrological droughts – based on two parameters expressing event intensity, i.e. deficit volume and duration – according to the following scheme: (i) short-term low flow, (ii) long-term low flow, (iii) moderate hydrological drought, (iv) deep hydrological drought, (v) extreme hydrological drought;
- introduction of hydrological drought definition – as a random phenomenon characterized by deficit volume and duration;
- methodological and application approach to presenting low flows and hydrological droughts in spatial and temporal perspective;
- index based assessment of droughts;
- development of drought forecast based on statistical method – using index based drought assessment;
- introduction of the concept plausible extreme hydrological drought – which, from the point of view of drought process and sequence of events, is real;
- assessment of water resources in diverse conditions – as hydrological information for the needs of planning, construction of hydrotechnical objects and water management;
- development and verification of three hybrid models: (i) hydrological drought indicator based on catchment drought vulnerability indicator, (ii) relative flow deficit based on recession coefficient, (iii) probability of above zero deficit volume based on retention of dynamic groundwater resources active exchange zone;
- introduction of hydrometeorological analysis for extrapolation of low flow and hydrological drought data from controlled catchments to ungauged catchments –

confirming the occurrence synchronicity of climatic water balance and hydrological droughts.

Table 1. Quantitative summary of scientific achievements

No.	Specification	Before doctorate	After doctorate	Total
1.	Monographs: a. sole author b. editor and co-editor		3 2 3	3
2.	Scientific publications: a. ISI Master Journal List – sole author [in print] – co-author [in print] b. Monograph chapters: c. international journals and publishers d. Polish journals and publishers	2 2	55 [5] 1 4 [3] 14 2 [1] 34 [1]	57 [5] 1 4 [3] 14 2 [1] 36 [1]
3.	Popular science publications		3	3
4.	Patent application	-	-	-
5.	Unpublished research works: a. realized within projects commissioned by State Committee for Scientific Research/Ministry of Scientific Research and Information Technology b. international projects (including EU co-funded projects) c. works commissioned for the needs of economy and by the Ministry of Environment, National Fund for Environmental Protection and Water Management, Regional Fund for Environmental Protection and Water Management,		41 4 12 25	41 4 12 25
6.	Total [in print]	2	103 [5]	105 [5]

7. Professional and didactic activities and professional qualifications

Concurrently with the scientific-research activities, I have continued to improve my professional qualifications. The following list presents only the events where I presented finding of the conducted research:

- 1995-2010 – participation in the LOW FLOW Group workshops,
- 1996 – 2012 – annual participation in School *Current hydrological issues* organized by the Water Management Committee,

- 1997 - participation in *Integrated Water Resources Management in Rural Areas* workshops within the TEMPUS Programme, Poland, organized by the Warsaw University of Life Sciences (SGGW),
- 1998, 2002, 2003, 2004, 2006 - 2009 – participation in *Mathematical Applications Seminar* organized by the Faculty of Mathematics at the Wrocław University of Environmental and Life Sciences,
- 2002, 2003 – participation in European Flood Forecasting System (EFFS) workshops, Ispra, Italy– testing meteorological forecasts as model input,
- 2003 - participation workshops on *Real Time Flood Decision Support System Integrating Hydrological, Meteorological and Remote Sensing Technologies*, University of Cambridge, UK – hydrological precipitation-runoff modeling using radar data for precipitation distribution in catchment,
- 2003 – participation in workshops on *Hydrological Drought for Water Management* organized within the *Analysis, Synthesis and Transfer of Knowledge and Tools on Hydrological Drought Assessment through a European Network* (ASTHyDA) project, Montpellier, France – development of methods and tools for hydrological drought assessment, monitoring, management and mitigation,
- 2004 – participation in workshops on *Real Time Flood Decision Support System Integrating Hydrological, Meteorological and Remote Sensing Technologies* Lueneburg, Denmark – hydrological precipitation-runoff modeling,
- 2004 – participation in workshops and seminar *Waters in Central and Eastern Europe: Assessment, Protection, Management*, Leipzig, Germany,
- 2004 – participation in workshops on *Real Time Flood Decision Support System Integrating Hydrological, Meteorological and Remote Sensing Technologies*, National Environmental Research Institute, Roskilde, Denmark – integration of meteorological model and hydrological precipitation-runoff model,
- 2005 – participation in workshops on *Real Time Flood Decision Support System Integrating Hydrological, Meteorological and Remote Sensing Technologies*, University of Bristol, U.K. – using special data in precipitation-runoff modelling,
- 2006 – participation in workshops on *Regional Climate Change: consequences for land-use and water management*, Technische Universitaet Bergakademie, Freiberg, Germany – impact of climate change on river runoff, methods assessment and reflecting theses changes in hydrological models,
- 2007 – participation in workshops on *Earth: our changing planet* organized by the International Union of Geodesy and Geophysics (IUGG) within the XXIV General Assembly, Perugia, Italy,
- 2009 – participation in workshops on *Drought & Natural System (Climate & Hydrology)* organized within the project *An Exercise to Assess Research Needs and Policy Choices in Areas of Drought* (XEROCHORE), 7th EU Framework Programme, Netherlands – integrated management of water resources and decision support system in the context of impacts of drought on socio-economic development.

As part of my didactic activity, in 1995-1999, I conducted a course of hydrology for the second year students, practical training in hydrology and field training in river regulation at the Faculty of Engineering at the Wrocław University of Environmental and Life Sciences.

In 2003 as part of my participation in School *Current hydrological issues*, I gave a lecture on *Hydrological droughts* and, in 2012, lecture on *Index based hydrological drought assessment*. In the academic year 2006/2007, I conducted courses of hydrology at the Faculty of Environmental Engineering and Geodesy of the Wrocław University of Environmental and Life Sciences during my training for Qualifications for elaboration of hydrological documentation

In total, I participated in 45 conferences, 35 seminars in Poland and 38 workshops abroad where I presented research findings. The most important are:

- **Tokarczyk T.**, Dubicki A., Kupczyk E., Suligowski R., 2005. *Assessment of drought potential risk for Upper and Middle Odra Watershed*, EGU, Vienna, www.copernicus.org/EGU;
- Jakubowski W., **Tokarczyk T.**, 2007. *The maximum low flow parameters depending on assumed threshold level*, XXIV Conference "General Assembly Earth, Our Changing Planet", http://www.iugg2007perugia.it/webbook/, Perugia, Italy;
- **Tokarczyk T.**, Szalińska W., 2010. *The concept of the operational drought hazard assessment scheme*. EGU General Assembly 2011, Vienna, Austria.

8. Organizational activities

My scientific-research work and professional work also includes development of my own research and coordination of multi-disciplinary teams providing scientific and organizational direction. As part of my professional activities, I participated in the organization of 5 conferences and a number of seminars.

An important form of my organizational activity for the development of science was the participation in preparation of applications of projects finances or co-financed from the funds of European Union:

- 2006-2007 project *Regional Adaptation to Climate Extremes AD 2040 (RACE 2040)* within the 7th EU Framework Programme;
- 2008 - project *Improved Information and Awareness for better Regional Governance on Water Risks (WATEREG)* within the European Regional Development Fund – Interreg IVC – Pilot project;
- 2008-2009 – project *Safety against HYDraulic RIsk in urban Centres (S.HYD.RI.C)*, within the European Regional Development Fund – Interreg IVC;
- 2008-2009 - *Regional Strategies for Disaster Prevention (Civ Pro)* Regional Strategies for Hazard Prevention within the European Regional Development Fund – Interreg IVC;
- 2009 - *Sensing Real World Phenomena and Predicting their Impact (ImpactSens)* within the 7th EU Framework Programme.

Furthermore, my organizational activities include participation in preparation of seven project applications to the EU commissions of which one was accepted. This motivated me to undertake a deeper study of preparation of project application forms, research project management and commercialization of research results.

I cooperate with a number of Universities and institutions in the field of water management both in Poland and abroad on a daily basis. I represented the Institute of Meteorology and Water Management- National Research Institute on numerous occasions in meetings organized for the purpose of "finding partners" for EU projects. I have organized meetings and workshops as part of realized national and international projects.

9. Membership and participation in international organizations

In 1995-2001 I was a member of the LOW FLOW Expert Group working within the research programme *Flow Regimes from International Experimental and Network Data*, closely connected with the International Hydrological Decade (IHD) sponsored by UNESCO.

Since 2000 I am a member of Polish and Czech Expert Group for Methodology for Hydrological Data Processing, a cooperation between the Institute of Meteorology and Water Management –National Research Institute and Ćeský Hydrometeorologický Ústaw (CHMU).

Since January 2011 I am a member of the Expert Group, a part of Workgroup G2"Flood" acting within the International Commission for the Protection of the Odra River against Pollution (ICPO). Main tasks of the Expert Group include coordination of activities resulting from the implementation of Directive 2007/60/EC of the European Parliament in the transboundary area of the Odra River basin.

Since October 2012, I have been representing Poland in the WMO Commission of Hydrology (CH-y) in Geneva.

10.Membership in scientific boards, committees Polish Academy of Sciences and scientific organizations

In 2003-2006 I was a member of Hydrological Section of the Water Management Committee (WMC) of the Polish Academy of Sciences (PAS). I have been appointed the scientific secretary of the WMC PAC at the Division IV Technical Sciences of the Polish Academy of Sciences for the term of office of 2011-2014.

In 2009-2012 I was a member of the 6th term of office of the Scientific Board of the Institute of Meteorology and Water Management –National Research Institute. Presently I am a member of the 7th term of office of the Scientific Board.

I am an active member of many scientific and professional organizations:

- 1997-present, Polish Geophysical Association, since 2004 member of the Board of the Wrocław Branch,
- 2007-present, Polish Association of Hydrologists, member of the Board,
- 2005-present, the European Drought Centre, member.

11. Awards and Acknowledgements

My professional accomplishments were recognized with following awards and acknowledgements:

- Minister of the Environment Award for the outstanding research accomplishments in the field of environment protection, management and natural resources use, 2002.
- Minister of the Environment Award for the outstanding research accomplishments in the field of environment protection, management and natural resources use, 2003.
- Badge of *Merit for Environmental Protection and Water Management*, 2008.
- Commemorative Medal *60th Anniversary of the Institute of Meteorology and Water Management*, 2008
- Commemorative *Medal 90th Anniversary of the State Hydrological-Meteorological Service PSHM*, 2009
- Award of General Director of the Institute of Meteorology and Water Management – National Research Institute in: 2005, 2007, 2008, 2009, 2010.

T. Tokarczyk

Wrocław, 25 April 2013 r.

Ph.D., Eng. Tamara Tokarczyk