भारतीय मानक

Indian Standard

IS 14654 : 2024

जलाशयों से वाष्पन क्षति कम करना — दिशानिर्देश

(पहला पुनरीक्षण)

Minimizing Evaporation Losses from Reservoirs — Guidelines

(First Revision)

ICS 93.160

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Reservoirs and Lakes Sectional Committee, WRD 10

FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Reservoirs and Lakes Sectional Committee had been approved by the Water Resources Division Council.

Water resources of the country had been considered to be exhaustible and its limited availability has been pausing a serious concern for future survival of mankind. Due to intensive agricultural practices, increase in population, rapid industrialization, urbanization, etc. scarcity of water is now being increasingly felt in many parts of the country. It is not uncommon these days to transport water over long distances by train or other mechanical means. It has therefore, become imperative that wastage of water should be controlled in all usages and every effort should be made to conserve water.

It is an established fact that huge quantity of water is lost annually from reservoirs and other water bodies by way of evaporation. Substantial quantity of water could be conserved by control of evaporation. This standard gives guidelines about various methods available for evaporation control including control of evaporation by chemical method. Available information on laboratory and field experiments conducted by various agencies for evaporation control was taken into account while formulating the standard.

In this revision of the standard, the following major modification have been are incorporated. Modern methods like modular systems, biological covers, shade ball method, for controlling evaporation. Also new chemical retardants are added in method of use of chemical retardants to control evaporation.

The composition of the Committee responsible for the formulation of this standard is given in Annex E.

For the purpose of deciding whether a particular requirement of this standard is complied with the final value, observed or calculated, expressing the result of a test or analysis shall be rounded off in accordance with IS 2 : 2022 ‘Rules for rounding off numerical values (*second revision*)’. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

MINIMIZING EVAPORATION LOSSES FROM RESERVOIRS — GUIDELINES

(First Revision)

1 SCOPE

This standard gives guideline for reduction of evaporation losses from water bodies including the use of chemical retardants to control evaporation. The standard also indicates the available measures to control the evaporation.

2 REFERENCES

The standards listed in Annex A contain provisions which through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of these standards.

3 TERMINOLOGY

For the purpose of this standard, the following definitions shall apply:

3.1 Collapse Pressure — The lowest pressure at which the monolayer collapses.

3.2 Equilibrium Spreading Pressure — The surface pressure of a mono-molecular film which exists when a solid or drop of the material is in equilibrium with a monolayer.

NOTE — Monolayer and mono-molecular film are the same. Molecules of chemicals like hexacosanal or hexadecanol show a unique property when in contact with water. The molecules stand on ends like bristles of brush with one end attracted to water and other end repelled by it. If the chemical is in sufficient quantity, the molecules spread on water surface and join tightly with each other forming a layer called monolayer or mono-molecular film.

3.3 Evaporation — The process by which water is changed from the liquid state into the gaseous state below the boiling point through the transfer of heat and wind energy.

3.4 Evaporation Retardants or Evapo-Retardants — Chemicals capable of forming a thin mono-molecular film on the water surface which reflects energy inputs from atmosphere and thus reducing evaporation.

3.5 Film Pressure — The difference between the surface tension of water and the surface tension of water covered with a monolayer.

3.6 Indicator Oil — A solution of light mineral oil or other suitable oil used for field identification of monolayer.

3.7 Self-Sealing Monolayer — Monolayer having the property of re-sealing itself on being ruptured or broken by wind boats, raindrops, etc.

3.8 Surface Tension — A phenomenon peculiar to the surface of liquids in which the surface molecules seem to have a greater cohesion with one another than the molecules in the body of the liquid so that the surface acts like a stretched elastic film.

3.9 Wind Breakers — A barrier composed of trees, shrubs or other vegetation planted around the periphery of the reservoirs for reducing the velocity of wind over the water surface in order to retard evaporation.

4 METHODS OF EVAPORATION CONTROL

4.1 A number of factors affect the evaporation from open water surface, of which, the major factors include water spread area and frequent change of speed and direction of wind over the water body. Other meteorological factors like vapour pressure difference between water surface and the layer of air above, temperature of water and air, atmospheric pressure, radiation, heat storage in water body, and quality of water have direct influence on the rate of evaporation. Since the meteorological factors affecting evaporation cannot be controlled under normal conditions, efforts are made for inhibition of evaporation by control of flow of wind over water surface or by protection of the water surface area by physical or chemical methods. The methods generally used are as follows:

a) Wind breakers;
b) Covering the water surface;
c) Reduction of exposed water surface;
d) Integrated operation of reservoirs; and
e) Treatment with chemical water evaporetardants (WERs).

4.2 Wind Breakers

4.2.1 Wind is one of the most important factors which affect the rate of evaporation loss from water surface. The greater the movement of air over the water surface, greater is the evaporation loss. Planting of trees normal to windward direction is found to be an effective measure for checking of evaporation loss. Plants (trees, shrubs or grass) should be grown around the rim of tanks in a row or rows to act as wind breaker. These wind breakers are found to influence the temperature, atmospheric humidity, soil moisture, evaporation and transpiration of the area protected.

4.2.2 Plants to act as wind breakers are usually arranged in rows with tallest plants in the middle and the smallest along the end rows so that more or less conical formation is formed.

4.2.3 Trees grown as wind breakers are constantly subjected to usual stress of wind, temperature, moisture, evaporation, insects and diseases. Thus, plants selected as wind breakers should be capable of resisting, these stresses. The list of vegetation for planting as wind breakers in different regions of India is given in Annex B. The spacing between plants varies from place to place depending on the climate and type of the soil.

In general, the following spacings are recommended:

Shrubs	0.60 m to 1.00 m
Medium height broad leaved trees	1.50 m to 2.00 m
Medium to tall evergreen trees	2.10 m to 2.40 m
Tall broad leaved trees with conical crown	2.40 m to 3.00 m

4.2.4 Spacing of plants at 3 m or more is found to have little effect in reduction of wind velocity over the protected area.

4.2.5 Wind breakers are found to be useful under limited conditions for small reservoirs. In large reservoirs, wind breakers are not effective, as their action is limited to a short distance from the rim of the reservoir, thereby exposing the inner water spread area to the hazards of wind.

This method has also the disadvantage of large quantity of water being lost due to transpiration by the trees planted. The wind breakers may therefore, be employed in specific high wind locations. In such locations, chemical method of evapo-retardation may not be feasible as the monolayers of water evaporetardants (WER) are found to break due to high wind velocities.

4.2.6 Use of synthetic poly-trees and poly-shrubs are also useful for creating barriers against the wind. This type of wind breakers can be raised in least possible time. However, the effectiveness of thesesynthetic plants and their economy in conservation of water is yet to be established.

4.3 Covering the Water Surface

4.3.1 Covering the surface of water bodies with fixed or floating covers considerably retards evaporation loss. These covers reflect energy inputs from atmosphere, as a result of which evaporation loss is reduced. The covers literally trap the air and prevent transfer of water vapour to outer atmosphere.

4.3.2 Fixed covers are suitable only for relatively small storages. For large storages, floating covers or mat or spheres may be useful and effective. However, for large water surfaces the cost of covering the surface with floats is prohibitive, further in case of reservoirs with flood outlets, there is also the danger of floats being lost over spillway or through outlets. The floating covers are thus of limited utility to larger water bodies.

4.3.3 Reservoirs offer large surface for potential solar power generation. The installation of floating solar panels on the reservoir may be considered based on technical and economic viability on case to case basis. For large water surface, the overall cost of covering the surface with floats would much be lower if the solar panels are installed on the floating platforms. While designing the solar panel cover, consideration must be given to the fact that the extent of water surface and its elevation will vary from minimum draw down level to full/maximum reservoir level. The percentage coverage of reservoir area by solar panels and the suitable area to be covered, may be explored after considering various aspects such as flora and fauna, aquatic life, environment, tourism, navigation, and the safety of the hydraulic structure.

NOTE — The use of solar panels on canal surface area or on the reservoir surface area has already been installed in number of projects. The advantages of solar installation are:

a) No separate land acquisition is required, which is, otherwise costly for the solar installations;

b) Due to extensive coverage of water surface area, there is substantial decrease in evaporation;

c) The economics of solar power generation works out well;

d) It is non-conventional, renewable,environment friendly energy option; and

e) With advances in the technology of Solar cells, per unit cost of the Solar Panels is decreasing substantially.

4.4 Reduction of Exposed Water Surface

In this method shallow portions of the reservoirs are isolated or curtailed by construction of dykes or bunds at suitable locations. Water accumulated during the monsoon season in such shallow portions is diverted or pumped to appropriate deeper pockets in summer months, so that the shallow water surface area exposed to evaporation is effectively reduced.

4.5 Integrated Operation of Reservoirs

This method is suitable for a system of reservoir which can be operated in an integrated way. The method consists of operating the reservoirs in such a way that total exposed water surface area is kept minimum during the depletion period. Consequently, evaporation loss gets minimized. For achieving this objective water use should be planned in such a way that shallow reservoirs with large water spread area are depleted first.

4.6 Treatment with Chemical Water Evapo-Retardants (WERs)

4.6.1 Chemicals capable of forming a thin monomolecular film have been found to be effective in reducing evaporation loss from water surface. The film so formed reflects energy inputs from atmosphere, as a result of which evaporation loss is reduced. The film allows enough passage of air through it and hence, aquatic life is not affected. The film developed by using fatty alcohols of different grades is found most useful for control of evaporation. These materials form a film of mono-molecular layer when applied on water surface which works as a barrier between water body and the atmospheric conditions. These fatty alcohols used for evaporation control are generally termed as chemical water evapo-retardants (WERs) and these are available in the form of powder or emulsion.

4.6.2 These chemical water evapo-retardants have the disadvantage of high cost of application. However, when adopted in scarcity period, drought, etc, the quantity of water saved by this method would work out cheaper than alternate means of bringing water from far off places manually or by mechanical transport. The economics of WER application may however vary from site to site depending on local factors. The chemical water evapo-retardants have another limitation of the monolayer breaking at high wind velocities.

5 PROPERTIES OF CHEMICAL WATER EVAPORETARDANTS MONOLAYER

5.1 For evaporation control, WER used shall have the following basic properties:

a) It should spread easily and form a compact, cohesive and even mono-molecular film on water surface;
b) The thin film formed by spreading WER should be pervious to oxygen and carbon dioxide, but tight enough to prevent escape of water molecules;
c) It should be sufficiently durable and should reseal itself, in case it is broken due to external disturbances as wind, waves, etc. The pressure of film so formed is also found to have a definite relation to the efficiency of the monolayer;
d) The chemical WFR should be tasteless, odourless, non-toxic and non-inflammable. It should have no effect on quality of water and aquatic life; and
e) It should not be affected by water borne bacteria, proteins and other impurities in the water.

5.2 Compounds having the above desired properties which are mainly used for evaporation retardation, are cetyl alcohol or hexadecanol ($C_{16}H_{35}OH$), stearyl alcohol or octadecanol ($C_{22}H_{45}OH$) and behenyl alcohol ($C_{18}H_{37}OH$), or a mixture of these compounds. All these alcohols should be 99 percent pure for getting the desired properties of monolayer.

5.3 Indicator Oils

For effective retardation of evaporation, the molecular film formed should develop adequate pressure. In most cases the initial film pressure is in the range of 20 dynes/cm^2 to 30 dynes/cm^2 and equilibrium pressure of 40 dynes/cm^2 can be achieved with appropriate dosage. For testing the pressure of WER film, oils of known spreading pressure (indicator oils) are used. The surface pressure developed by certain indicator oils are given in Annex C.

6 GUIDELINES FOR USE OF CHEMICAL WERs

6.1 The guidelines given in **6.2** to **6.6** are suggested for using WER in arid, drought prone or water deficit areas. These are broad guidelines only and may be varied depending on the site conditions or according to the manufacturer’s specification for WER and equipment used.

6.2 Application in Emulsion Form

6.2.1 The dose of emulsion per day may be 500 g/ha of open water surface for initial 15 days. It can be reduced to 250 g/ha in the subsequent periods of application. The required quantity of emulsion may be diluted with water 20 times to 25 times by volume for ease of application. Mixing of emulsion with water may be done either manually or mechanically. The later, however, gives more homogenous mix. The diluted mix is then filtered to separate put lumps or impurities which could block the dripping line.

6.2.2 Application of the solution is done by dripping from storage drums fixed on floating rafts or on shore dispensers. A drum of 30 litre capacity may approximately cover one hectare of water surface area whereas a drum of 200 litres capacity may approximately cover an area of 7 ha. Four drips may be provided in a 200 litre capacity drum, while two drips may be provided in a 30 litre capacity drum.

6.2.3 The floating rafts may be positioned on water surface in grids of size depending on the capacity of the drums so that the entire area of the water surface is covered. The rafts should be anchored to avoid drift. In case the site condition does not permit anchoring of floating rafts and the reservoir to be treated is comparatively small, the drums may be mounted on shore dispensers positioned along the periphery of the reservoir. Prevailing wind direction helps in spreading and building of a film.

6.2.4 Heavy wind velocity and changes in wind direction may break the monolayer and thus special efforts are required for the maintenance of the film after such events. Presence and continuity of the film can be ascertained by putting a drop of an indicator oil like castor oil on the treated water surface. If the drop of the indicator oil maintains its shape, it shows the presence of the film.

6.3 Application in Powder Form

6.3.1 The suggested dose for application of WER in powder form is approximately 75 g/ha of water surface per day. As the powder is supplied in lump form, it is required to be pulverised into a fine powder form by using a manual or mechanical pulveriser. The powder can be dispersed on water surface from boat by means of manually operated dusters.

6.3.2 For quickness and economy in application, two dusters may be fixed on either side of the boat. Speed of the boat should be regulated in such a way that minimum disturbances occur on the water surface, while completing the dusting as quickly as possible. Depending on the area of water spread, passes of the boat are suitably arranged while taking advantage of the wind direction.

6.3.3 Presence of the film on water surface may be ascertained as in the case of emulsion form. About 10 percent to 15 percent of the daily dose of WER may be kept reserved for use whenever the film is broken.

6.3.4 Depending upon local conditions, a method of combining the use of emulsion and powder forms is generally found optimal. During the night, WER solution may be applied using drips on floating rafts located suitably in the reservoir. During the day, WER powder can be sprayed for maintenance of continuous film, taking into account the wind direction.

6.4 Quality of Water

During the course of application of WER for evaporation control, the quality of water may be monitored and effects on the same shall be carefully studied.

6.5 Equipment

The equipment required for spreading WER and for assessing the saving in evaporation loss are given in Annex D.

6.6 Guidelines for Testing Film Pressure

The pressure that a monolayer build on the treated surface of water can be indicated approximately by use of oils of known spreading pressures.

The spreading pressure of various oils are given in Annex C. A small drop of any of these oils is applied over the monolayer, whose pressure is to be assessed. If the indicator oil drop spreads, it is evident that water surface carries a film at a pressure lower than spreading pressure of indicator oil. If the drop does not spread, it indicates that the film pressure is greater than the spreading pressure of the indicator oil. Oils of different spreading pressures in the working range should be kept ready at the site before field application of WER.

7 OTHER METHODS FOR CONTROLLING EVAPORATION LOSS

7.1 Modular Systems

Modular floating covers come in a range of sizes typically up to 3 m^2 in area and act in a similar manner to floating covers. Shade structures in general are suspended above the water surface using cables creating a web-like structure with shade cloth fitted between the cables.

7.2 Biological Covers

Floating plants Floating aquatic plants such as water lily, small duckweed, great duckweed and water meal can reduce the evaporation of water reservoirs by preventing the connection between air and the boundary layer of water.

7.3 Shade Ball Method

Shade balls are small plastic spheres, which are floated on the water surface of reservoirs to slow evaporation losses.

ANNEX A

(*Clause* 2)

LIST OF REFERRED INDIAN STANDARDS

IS No.	*Title*
IS 5235 : 1992	Meteorology — Raingauges recording — Specification (*first revision*)
IS 5681 : 1992	General meteorological thermometers, liquid-in-glass — Specification (*second revision*)
IS 5793 : 1970	Specification for aneroid barometers
IS 5798 : 1970	Specification for mercury barometers
IS 5799 : 1970	Specification for windvane
IS 5948 : 1970	Specification for thermometer screens
IS 5973 : 1998	Pan evaporimeter — Specification (*first revision*)
IS 6939 : 1992	Methods for determination of evaporation from reservoirs (*first revision*)
IS 7243 : 1974	Specification for sunshine recorder

ANNEX B

(*Clause* 4.2.3)

RECOMMENDED TREE, SHRUB AND GRASS SPECIES FOR DIFFERENT REGIONS OF INDIA

Northern Region (Plains of Punjab, Haryana, Uttar Pradesh, Delhi and Parts of Gujarat and Madhya Pradesh)

Botanical Names	Standard Trade Names	Habitat
Acacia nilotica A	babool	T
Jacquemontii	bouli	ST
Albizia lebbeck	kala siris	T
Arundo donax	baranal	S
Agave americana	grit kumari	S
Capparis decidua	kair	S
Dalbergia sissoo	shisham	T
Euphorbia royleana	thar	S
Impomoea crassicaulis	besharam	S
Jatrohpa curcas	ratan jyoti	S
Ktek negundo	nirgandi	S
Lawsonia inermis	mehandi	S
Parlinsonia aculeata	uilayati keekar	ST
Sasharum bengnalensis	munj	G
Syzygium cumini	jamun	T
Sesbania sesban	jayanti	S
Tecoms stans	sonnapatti	S
Tamarix aphylla	farash or jhau	T
Thevetia peruviana	kaner	S
Ziziphus nummularia	ber	S

Central Region (Parts of Gujarat, MP, Andhra Pradesh and Maharashtra)

Botanical Names	Standard Trade Names	Habitat
Acacia nilotica A	babool	T
ctechu	khair	T
Agave sislana	grit kumari	S
Boswellia serrata	salai	T
Cassia siamea	siamea	T
Dalbergia latifolia	sitsal	T
Gliricidu maculota	madre	ST
Hardwicxia binata	anjan	T
Jatropha curcas	ratan jyoti	S
Meliu azadirachtu	bakain	T
Pithecellobium dulcis	jangal jalebi	ST
Pongamia pinnata	karanj	T
Ricinus communis	arand	ST
Sesbania grandiflora	basna	ST

Southern Region (Tamil Nadu, Parts of Andhra Pradesh, Karnataka and Kerala)

Botanical Names	Standard Trade Names
Acacia nilotica	babool
A auriculiformis	wattle
A decurrens	blackwattle
Agave sp.	grit kumari
Anacardium occidentale	kolamavu
Albizia lebbeck	magei
Bombusa sp.	mungli
Borassus jlabellifer	panei
Casuarina equisitifolia	hauku
Erythrina spp.	mulu moduyu
**Eucalyptus* spp.	eucalyptus
Gliricida maculata	-
Grevillea robusta	silveroak
Jatrophu curscas	nepalam
Pueraria javanica	-
Sesbanta sesban S	chittikatti
bispinosa	jayanti
Telphrosia candida	lashtia

Eastern Region (West Bengal, Assam, Orissa and Bihar)

Botanical Names	Standard Trade Names
a) Inland areas	
Acucia cutechu	khair
Aguve sisluna	kantala
Anacnrdium occidentule	kaju
Artoarphus heteroph.yllus	kathal
Arundo donux	gaba nal
&unhusa sp.	bans
Borcissus ,flahellifer	tal
Casuurincl ecluisetifolia	janguli saru
Cocos	narial
Dulbcrgia .sissoo	shisham
lmperata cylindrica	ulu
Lunnea caromandetica	jhingal
Musa paradisiaca	jela
Syzygium cumini	jamun
Tqhrosia candida	lashtia
Vitex negundo	nirgandi
b) Coastal areas	
Acacia acricuiformes	Sonejhur
Anacardium occidentale	kaju
Borassus flabellifer	tar
Casuarina equisitifolia	janglisaru
Cocos *nucifera*	narial
Delonix elata	gulmohar
Erythrina indica	polita mandas
Buphurbia tirucalli	sehund
Bicus spp	gad gubar
Indiqofera aspalathoides	sivanimba
Ipomoea biloba	natilata
Pongamia pinnata	karanj
Prosopis julijlora	vilayati babool
Inifex littorcus	Rawn moonch

Botanical Names	Standard Trade Names
Tamarix aphylla	farash
Thespsia populnea	paraspipa

Arid Region (Western Rajasthan, Part of Andhra Pradesh and Karnataka)

Botanical Names	Standard Trade Names
Acacia nilotica	babool
A leucophloea	reonja
A planifrons	Godugh thumba
A Senegal	kummet
A Tortilis	israelibabool
Balanites aegyptiaca	hingot
Calligonum polygonoides	phog
Capparis decidua	kair
Clerodendrum phlomldes	arni
Saccharum munja	munj
Eucalyptus camaldulensis	eucalyptus
Euphoribia caducifolia	thor
Lasiurus sindicus	sewan
Panicum trugidum	murat
Tamarix aphylla	farash
Zizyphus nummularia	jharber

T = Tree, ST = Small Tree. S = Shrub, G = Grass
Source : Technical Bulletin (AGRIC) No. 22. ICAR. New Delhi (1969) by J.K. Ganguly and R N. Kaul.

* May be planted only if permissible by Government Regulations

ANNEX C

(*Clauses* 5.3 *and* 6.6)

SURFACE PRESSURE OF INDICATOR OILS AT 21 °C

Sl No.	Indicator Oils	Surface Pressure Developed at 21 °C (dynes/cm²)
(1)	(2)	(3)
i)	Shell ensis fluid 256	40.0
ii)	Undocylic acid	34.5
iii)	Hexadecyl acetate	34.4
iv)	Oloic acid	30.0
v)	Octadecyl acetate	24.0
vi)	Shell vitrea oil 21	24.0
vii)	Triolein	22.0
viii)	Laurie acid	21.0
ix)	Castor oil	17.0
x)	Ethyl pholometite	16.5
xi)	Shell vitrea oil 13	16.0
xii)	She11 H.S.D.	13.0
xiii)	Triorozyl phosphate	10.0
xiv)	Myrystic acid	11.0
xv)	Palmitic acid	8.5
xvi)	Carbon disulphide	2.3
xvii)	Steanic acid	1.5

ANNEX D

(*Clause* 6.5)

EQUIPMENT REQUIRED FOR APPLICATION OF CHEMICAL WERs AND FOR ASSESSMENT OF EVAPORATION LOSS

Sl No.	Equipment	Purpose
(1)	(2)	(3)
i)	Motorized boat	Spraying WER
ii)	Dusters	Dusting WER
iii)	Pulverizers	Pulverizing WER
iv)	Floating raft and drums	Dripping WER

Sl No. (1)	Equipment (2)	Purpose (3)
vi)	Anchors/chains	Anchoring of rafts
vii)	Pan evaporimeter (land type) (IS 5973) - 2 Numbers (one in chemically treated condition and the other in untreated condition	Measurement of evaporation loss from treated water surface and from untreated surface
viii)	Anemometer - 1 Number	Measurement of wind velocity
ix)	Wind vane (IS 5799) - 1 Number	Observation of wind direction
x)	Thermometer screen (IS 5948) - 1 Number	Fixing and protecting thermometer
xi)	Dry and wet bulb – 1 set thermometer with conversion charts	Measurement of humidity
xii)	General Meteorological Thermometer (IS 5681) - 1 set	Measurement of minimum and maximum temperature during a day
xiii)	(IS 5235) - 1 Number	Measurement of rainfall
xiv)	Sunshine recorder (IS 7243) - 1 Number	Measurement of total sunshine hours during a day
xv)	Aneroid Barometer - 1 Number (IS 5793)	Measurement of atmospheric pressure
xvi)	Mercury barometer (IS 5798)	Measurement of atmospheric pressure

ANNEX E

(*Foreword*)

COMMITTEE COMPOSITION

Reservoirs and Lakes Sectional Committee, WRD 10

Organization	*Representative(s)*
National Institute of Hydrology, Roorkee	DR SUDHIR KUMAR DIRECTOR (***Chairperson***)
Bhakra Beas Management Board, Chandigarh	ER HUSHAN LAL KAMBOJ
Central Water and Power Research Station, Pune	DR NEENA ISAAC SHRI SRISHAILAM (*Alternate* I) DR V. M. PRABHAKAR (*Alternate* II)
Central Water Commission, New Delhi	SHRI GOVERDHAN PRASAD SHRI S. S. BONAL (*Alternate*)
Department of Water Resources, Govt of Punjab	SHRI PAWAN KAPOOR SHRI K. K. GUPTA (*Alternate* I) SHRI N. K. JAIN (*Alternate* II)
Department of Water Resources, Govt of Odisha	CHIEF ENGINEER (D & R) DIRECTOR (HEAD WORKS) (*Alternate*)
Indian Institute of Technology, Roorkee	PROF ARUN KUMAR PROF SUMIT SEN (*Alternate*)
Indian Institute of Technology Bombay, Mumbai	DR V. JOTHIPRAKASH
Irrigation Research Institute, Roorkee	SHRI DINESH CHANDRA SHRI SHANKAR KUMAR SAHA (*Alternate*)
J&K Lakes and Water Way Development Authority, Srinagar	EXECUTIVE ENGINEER
Maharashtra Engineering Research Institute, Nashik	SHRI YASHAVANT RAO BHADANE
Narmada Water Resources, Water Supply & Kalpasar, Gandhinagar	SHRI R. M. PATEL SHRI D. N. PRADHAN (*Alternate*)
National Institute of Hydrology, Roorkee	DR M. K. GOEL DR S. D. KHOBRAGADE (*Alternate*)
National Remote Sensing Centre, Hyderabad	DR V. VENKATESHWAR RAO SHRI ABDUL HAKEEM (*Alternate*)
National Thermal Power Corporation Limited, New Delhi	SHRI RAKESH SHARMA DR A. K. SINGH (*Alternate*)
National Water Academy, Pune	SHRI ASHOK KUMAR KHARYA SHRI S. N. PANDE (*Alternate*)
National Water Development Agency, New Delhi	SHRI R. K. JAIN SHRI S. C. AWASTHI (*Alternate*)
National Hydroelectric Power Corporation, Faridabad	MS MANJUSHA MISHRA MS ANKUR SHARMA (*Alternate* I) SHRI PRAVEEN KUMAR JAIN (*Alternate* II)

Organization	*Representative(s)*
Office of the Engineer-in-Chief, Bhopal	SHRI B. C. PURANDARE SHRI S. R. UIKEY (*Alternate*)
Sardar Sarovar Narmada Nigam Limited, Gandhinagar	SHRI C. V. NADPARA SHRI R. G. KANOONGO (*Alternate*)
Satluj Jal Vidyut Nigam Limited, Shimla	SHRI VINAY GULERIA SHRIMATI SUDHA DEVI (*Alternate*)
Tehri Hydel Development Corporation India Limited, Rishikesh	SHRI VIRENDRA SINGH SHRI ATUL KUMAR SINGH (*Alternate*)
Water and Power Consultancy Services Limited, New Delhi	DR A. K. SHARMA SHRI A. STEPHEN LEO (*Alternate*)
Water Resources Department, Govt of Maharashatra	SHRI RAJESH M. MORE SHRI A. P. KOHIKAR (*Alternate*)
Water Resources Department, Govt of Andhra Pradesh	SHRI A. SURI BABU
Wetlands International South Asia	DR RITESH KUMAR DIRECTOR SHRI HARSH GANAPATHI (*Alternate*)
In Personal Capacity, (*55/2 Amond Path, IIT Roorkee Campus, Roorkee - 247667*)	PROF M. L. KANSAL
In Personal Capacity (*514, IVA, Paschimabad, Multistorey JNU, New Delhi - 110067*)	DR A. L. RAMANATHAN
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