BENCHMARKING of CWPRS

Final Report for the World Bank

by

Pierre Y. Julien, Ph.D., P. Eng.

October 2012

TABLE of CONTENTS

EXECUTIVE SUMMARY **4**

1 - BENCHMARKING OBJECTIVES **6**

2 – TASK A: BENCHMARKING REVIEW OF THE CAPABILITIES AT CWPRS **7**

2.1 TASK A1 - Review comprehensively international agencies/institutes/organizations with similar mandate as CWPRS and establish an International bench mark **8**

2.1.1 - U.S. Bureau of Reclamation (USBR) in the USA **8**

2.1.2 - U.S. Army Corps of Engineers (USACE) in the USA **10**

2.1.3 - Delft Hydraulics/Deltares in the Netherlands **11**

2.1.4 - Sogreah/Artelia in Grenoble in France **12**

2.2 - TASK A2 - Determine the status of CWPRS vis-a-vis International bench mark **14**

2.3 - TASK A3 - Identify the gaps in the areas of research and the mandate of the Institute **18**

2.4 - TASK A4 – Suggest areas of expansion and upgradation both in terms of personnel, technology, infrastructure and equipments keeping 12th plan proposal in view **20**

2.4.1 - Strengths **20**

2.4.2 – Weaknesses **21**

2.4.3 – Opportunities **21**

2.4.4 – Threats **22**

2.4.5 - Suggestions for upgrading CWPRS **22**

2.5 - TASK A5 - Identify new areas of research keeping in view the National and International trends **27**

2.5.1 - Environmental – USBR **29**

2.5.2 - Environmental – USACE **30**

2.5.3 - Environmental - Deltares **31**

2.5.4 - Environmental – Artelia **32**

2.6 - TASK A6 – To identify training programmes in relevant areas **34**

3 - TASK B: STRENGTHENING OF CWPRS WITH SOFTWARE/EQUIPMENT IN ITS AREAS OF ACTIVITIES **36**

3.1 - Need to renovate the existing buildings **36**

3.2 - Need to build large facilities for the 21st Century **39**

3.3 - Need for new equipment and new computing capabilities **39**

4 - TASK C: TRAINING OF CWPRS PERSONNEL **42**
4.1 - Task C1 - Identify specialized subject areas vis-à-vis Institutions/ organization abroad for training of officials and detail the training course needs. **42**
4.2 - Task C2 - Assist CWPRS in corresponding with institutes for taking their consent for specialized trainings. **43**
4.3 - Task C3 - Draw up implementation schedule for training of personnel in national and international institutes over a period of 5 years during the 12th Plan period (2012-2017) including financial implications. **43**
4.4 - Task C4 - Suggest the international experts who may be invited to impart training at CWPRS in the identified specialized subject areas. **43**

5 - CWPRS - A WORLD-CLASS RESEARCH INSTITUTE **45**
5.1 - Gaps with world-class status **45**
5.1.1 - Emerging opportunities **45**
5.1.2 - Gaps with world-class facilities **47**
5.2 - Development Plan for CWPRS **49**
5.2.1 - New Research Officer Positions and Training **49**
5.2.2 - New Building #1 - Center for Eco-Hydraulic Research (CEHR) **50**
5.2.3 - New Building #2 - Welcome Center and Administrative Services (WCAS) **51**
5.2.4 - Renovations of Research Buildings and Equipment **52**
5.2.5 - Autonomous Status **53**
5.2.6 - Other Opportunities **54**
5.2.7 - Five Year Schedule **55**
5.2.8 - Budget **56**
5.2.9 - Closing Statement **57**

APPENDIX - A - Brief Report on the 1st Visit **58**

APPENDIX - B - Brief Report on the 2nd Visit **71**

APPENDIX - C - Detailed List of Equipment Needs at CWPRS **100**

APPENDIX - D - Detailed List of Training Needs at CWPRS **114**

EXECUTIVE SUMMARY

At the request of the WorldBank, this study aims at benchmarking, technological upgradation and capacity building of the Central Water and Power Research Station (CWPRS) in Pune, India. This report reviews the CWPRS activities as specified in the Terms of Reference (TOR). Under Task A of the TOR, CWPRS is compared with four other world-class Institutes: the USBR, the USACE, Delft Hydraulics/Deltares, and Sogreah/Artelia. It is important to consider that the conditions in other countries are different from those of India. Nevertheless, the analysis suggests that some current practices in the US and Europe may be considered in the prospective developments in India. In general, it has been found that the other Institutes have replaced most of their physical modeling activities with mathematical modeling. The four selected institutes also commit significant resources to environmental engineering. CWPRS should continue physical modeling activities and vigorously engage in the development of new eco-hydraulic research facilities. To meet the challenges and the needs in water resources infrastructure of the 21st Century, CWPRS should continue to prioritize national needs, but a gradual increase in international collaboration and research activities would be welcome. Details are found in Section 2.

CWPRS used to benefit from significant UNDP funding for the upkeep of its research facilities. After the UNDP funding ceased in 1998, it has been very difficult to maintain the research facilities. The number of sanctioned positions at CWPRS has also declined from 1857 in 2001 to 1172 in 2012. This significant decline in the work force and lack of support for the research facilities is opposite to the rapidly increasing demand for world-class research facilities and personnel to solve water-related problems in India. During my second visit, the equipment needs in terms of hardware and software for both physical and numerical modeling were reviewed per Task B of the TOR. The detailed needs for training have also been scrutinized per Task C of the TOR. This report provides a detailed listing of the equipment and training needs at CWPRS. Details are found in Section 3 for Equipment and Section 4 for Training.

In the new millennium, India has been subjected to a rapid increase in the needs for further development of its water resources infrastructure. The demand for better technology in the water areas emerges from:

(1) substantial demographic expansion;
(2) a tsunami that devastated the east coast of India on December 26, 2004;
(3) extreme rainstorms and flash floods in urban areas, e.g. the Mumbai flood July 26, 2005 with 944 mm of daily rainfall precipitation;
(4) earthquakes that have damaged some hydraulic structures, e.g. the Bhuj earthquake in Gujarat that caused liquefaction of the Chang Dam on January 26, 2001; and
(5) nuclear power plants that require hydraulic cooling, and for which the lesson learned from last-year's Fukushima meltdown should remind us of the utmost importance of world-class engineering expertise for the design of safe power plants facing natural and manmade disasters.

A detailed Development Plan for the next five years has been articulated in Section 5. The proposed development plan for CWPRS emphasizes the need to recruit the brightest and most talented engineers and scientists to meet the increasing challenges in the development of water resources. This five-year plan proposes to increase the number of research officers to meet the new opportunities for future development in water-related research. Two new buildings should be added for the development of eco-hydraulic research and for the development of high-performance computer modeling. The existing buildings should all be renovated and equipment should be upgraded or renewed. Large facilities are requested for: (1) the construction of the very first flume on tsunami research in India; (2) eco-hydraulic facilities for research on river restoration, urban flood control, and sediment management; (3) research laboratories in support of environmentally-friendly river ecosystems; (4) a large scale vibration table for the analysis of the impact of earthquakes on hydraulic structures; and (5) cavitation and thermal experimental facilities for the improved design of water cooling systems in nuclear and thermal power plants. CWPRS also needs to prepare to become autonomous. The resources required are about 90 cr (~$18,000,000 USD) within a period of 5 years. These resources aim to bring CWPRS among world-class institutions within five years. CWPRS should also celebrate 100 years of active research and expertise in water resources since the foundation of the Research Station in 1916.

1 - BENCHMARKING OBJECTIVES

Objectives of the Consultancy defined in the Terms of Reference (TOR):

To be in the forefront in the areas of its activities with world class standard, CWPRS plans to initiate an exercise on benchmarking to identify the gaps compared to the other similar institutes the world over and prepare a road map to bridge the gaps. To fulfill its commitment to the emerging challenges before the nation and to be able to take up works from other developing countries as well, there is a need for continuous strengthening and up gradation of the infrastructure facilities and to develop new areas of competence. Towards this end, it is planned to engage an international consultant to assist in this exercise. The international consultant will assist in the following areas:

a) Systematically reviewing the research infrastructure of CWPRS to identify the gap areas for making it a world class institute.
b) Conducting performance benchmarking regarding the quality of service currently delivered by CWPRS.
c) Identifying development of infrastructure facility by way of acquiring latest equipments and software and up gradation of existing facilities.
d) Planning for strengthening of existing areas of research and suggesting new areas of expansion in the sphere of activities of CWPRS
e) Planning for developing capacity of researchers by way of identifying areas and training institutions abroad in the thrust areas of research.

To assist CWPRS to achieve world-class standards, these objectives are covered in the following sequence in this report:

- Task A in Section 2 provides a benchmarking review of the capabilities at CWPRS and suggested new areas for expansion - objectives b) and d).
- Task B in Section 3 reviews the equipment and software needs – objective c).
- Task C in Section 4 provides more details on the training needs – objective e).
- Section 5 identifies the gaps and presents a Development Plan to make CWPRS a world-class institute – objective a).

2 - TASK A: BENCHMARKING REVIEW OF THE CAPABILITIES AT CWPRS

More specifically, the scope of work under Task A is the following:

Task A: Bench marking of CWPRS:

1. Review comprehensively international agencies/institutes/organizations with similar mandate as CWPRS and establish an International bench mark
2. Determine the status of CWPRS vis-a-vis International bench mark
3. Identify the gaps in the areas of research and the mandate of the Institute
4. Suggest areas of expansion and upgradation both in terms of personnel, technology, infrastructure and equipments keeping 12th plan proposal in view.
5. Identify new areas of research keeping in view the National and International trends.
6. To identify training programmes in relevant areas

For the first two bullet items, I carried out a review of peer institutions with similar functions around the world. For the last four bullet items, the first visit at CWPRS during the week of June 11-15, 2012 has been very successful and the set goals have been achieved. A detailed description of the work accomplished during this first visit can be found in Appendix A.

I will address each of the six bullet items listed above in itemized fashion. The purpose is clearly to provide a comprehensive review of the activities of CWPRS against a benchmark with peer institutions, identify gaps in research areas and suggest new areas for expansion and development of CWPRS in view of National and International trends. The last item identifies broad areas for training programs. The second visit during the week of July 23-27 provided additional details on the training programs and on the equipment/computer needs of CWPRS.

2.1 - TASK A1 - Review comprehensively international agencies/institutes/organizations with similar mandate as CWPRS and establish an International bench mark

For the benchmarking comparison, two institutions were selected in the United States: (1) the U.S. Bureau of Reclamation (USBR) and the U.S. Army Corps of Engineers (USACE). Two additional International Institutions have also been selected: (1) Delft Hydraulics, now Deltares in the Netherlands; and (2) and Sogreah, now Artelia, in Grenoble, France.

The following provides a brief overview of each Institution. I compiled additional information including Strategic Plans, Annual Reports, as well as Vision and Mission Statements. These institutions are reviewed in order of decreasing importance in relation with CWPRS. The following information has been extracted directly from their respective web sites.

2.1.1 - U.S. Bureau of Reclamation (USBR) in the USA

The mission of the USBR is fairly similar to the mandate of CWPRS. It focuses on water resources development and management in Western United States. It includes dam operation and management, hydropower, irrigation and drainage. It does not include navigation or coastal engineering. The main divisions of USBR are:

- Civil Engineering services
- Water and environmental resources
- Geotechnical services
- Power resources

Mission Statement

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Vision Statement

Through leadership, use of technical expertise, efficient operations, responsive customer service and the creativity of people, Reclamation will seek to protect local economies and preserve natural resources and ecosystems through the effective use of water.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

The Commissioner's plan for how Reclamation will attain its vision:

- Directing our leadership and technical expertise in water resources development and in the efficient use of water through initiatives including conservation, reuse, and research.
- Protecting the public and the environment through the adequate maintenance and appropriate operation of Reclamation's facilities.
- Managing Reclamation's facilities to fulfill water user contracts and protect and/or enhance conditions for fish, wildlife, land, and cultural resources.
- Working with Reclamation's customers and stakeholders to achieve mutual objectives.
- Assisting the Secretary in fulfilling Indian Trust responsibilities.
- Implementing innovative, sound business practices with timely and cost-effective, measurable results.
- Promoting a culturally diverse workforce which encourages excellence, creativity, and achievement.

Excerpt:

From the Commissionner R.W. Johnson: ”...In 2008, Reclamation worked with State, local, tribal, and other Federal partners, continuing to carry out our role in developing and maintaining one of the most impressive water management infrastructures in the world, which brings water and power to the people of the West and supports the region's economy. Our core mission, to deliver water and generate power in the 17 Western States, has remained constant for a century. The way we accomplish our mission has evolved considerably. Today, we focus more broadly on the management of water resources to ensure the safe and effective performance of our facilities, to implement innovative approaches to meet multiple current and future needs, and to bring additional benefits such as habitat restoration and recreation…”

Useful web links:

Organization Chart
http://www.usbr.gov/main/regions.html

Annual Report
http://www.usbr.gov/library/BRannualreports.html

Environmental Applications and Research Group
http://www.usbr.gov/pmts/eco_research/

2.1.2 - U.S. Army Corps of Engineers (USACE) in the USA

The mission of the USACE is also fairly similar to the mandate of CWPRS. The USACE emphasizes flood control, waterways, coastal engineering, and water resources development throughout the United States. It is not significantly involved in irrigation and drainage.

Mission
Provide vital public engineering services in peace and war to strengthen our Nation's security, energize the economy, and reduce risks from disasters.

Vision
A GREAT engineering force of highly disciplined people working with our partners through disciplined thought and action to deliver innovative and sustainable solutions to the Nation's engineering challenges.

Excerpt:

"…Responsible water resources engineering is not just the application of state-of-the-art science and technical skills. This strategic plan recognizes that USACE must continually develop and apply a diverse range of planning, problem solving, and evaluation strategies while broadening its knowledge, skills, and talents. The USACE must be both a leader and a partner in these efforts. This strategic plan presents USACE's commitment to responsibly develop the Nation's water resources, while protecting, restoring and sustaining environmental quality. USACE is dedicated to learning from the past and adapting the organization to ensure the U.S. enjoys a prosperous and sustainable future…."

Useful web links:

Civil Works Strategic Plan
http://www.usace.army.mil/Portals/2/docs/civilworks/news/2011-15_cw%20stratplan.pdf

Centers of Expertise
http://www.usace.army.mil/About/CentersofExpertise.aspx

Environmental Program
http://www.usace.army.mil/Missions/Environmental.aspx

2.1.3 - Delft Hydraulics/Deltares in the Netherlands

Delft Hydraulics used to be one of the world largest agencies for flood control and coastal protection works. The operations have been rescinded into Deltares about one decade ago. There are 4 divisions in Deltares:

- Coast and Sea
- Rivers, Lakes and Groundwater
- Soil and Subsurface
- Policy and Planning

Mission

The Deltares mission is as follows:
Developing and applying top-level expertise in the area of water, subsurface and infrastructure for people, planet and prosperity.

Deltares is an independent institute that provides a high standard of expertise and advice. We work closely with governments, businesses and research institutes in The Netherlands and abroad. Deltares delivers economic added value, acting with social responsibility and constantly searching for answers for society as a whole. In doing so, we draw on both our own expertise and the knowledge of others.

By 2015, Deltares aims to be among the world's top in its field of work, by continuing to build and consolidate its knowledge base. As an applied research institute, the success of Deltares depends on the extent to which its knowledge is applicable in and for society. After all, the Deltares motto is *Enabling Delta Life*

Useful web links:

Strategic Plan 2012 – 2015 & Corporate Brochure
http://www.deltares.nl/en/about-deltares

Annual Review 2011
http://www.deltares.nl/media/jaarverslag/2011/en/files/assets/downloads/publication.pdf

Coast and Sea
http://www.deltares.nl/en/coast-sea

Rivers, Lakes and Groundwater
http://www.deltares.nl/en/rivers-lakes-groundwater

Soil and Subsurface
http://www.deltares.nl/en/soil-subsurface

Policy and Planning
http://www.deltares.nl/en/policy-planning

2.1.4 - Sogreah/Artelia in Grenoble, France

Sogreah used to be one of the world leading international agencies in hydraulics and hydropower half a century ago. They provided tremendous education and applied research opportunities. More recently Sogreah has been reorganized into Artelia. There are four sections in Artelia

- Buildings and Industrial Facilities
- Water and Environment
- Urban Development and Transportation
- Artelia International

Our QHSE policy

Deeply involved in industrial projects on behalf of major clients located throughout the world, Artelia is committed to developing an Quality Health and Safety Environment QHSE policy that is also of benefit to its non-industrial clients in the public and private sectors. This policy is coordinated by the group's Quality Assurance and Safety Department. The group is endeavouring to develop and expand its expertise through internal and external growth operations.

Some of our teams, particularly those that work in the industrial sector, have ISO 14001 certification and the aim is to extend this to the entire group. Artelia also has numerous other environmental qualifications, such as Qualipol in France, that are adapted to each sector of activity.

Health and Safety

Artelia considers health and safety to be crucially important issues of daily concern, first and foremost for our staff, but also for future users of the buildings and infrastructure that we design and for everyone working on the construction sites that we supervise. This culture enables our associates to adapt to the specific requirements of our clients and to advise them on health and safety issues. HEALTH AND SAFETY As required by French law, each of the group's units has a regularly updated workplace risk assessment document suited to the context and nature of its activities. Most of the group's entities have OHSAS 18001 certification.

Providing clients with quality services is a fundamental objective for Artelia.

Quality

Coteba's and Sogreah's management systems have had ISO 9001 certification for many years. Artelia is developing a single management system based on the two existing systems, making sure that the certifications remain valid.

Environment

Artelia strives to reduce the impacts created by its own activities and takes the environment into account in all the projects it handles.

Artelia has extensive environmental expertise in the fields of water, renewable energy, carbon strategies, climate change, biodiversity, energy-saving buildings, sustainable cities, natural and industrial risk management, soil and groundwater studies and remediation and environmental management.

Useful web links:

Organization Chart
http://www.arteliagroup.com/en/system/files/publications/artelia_organization_06_2012_en.pdf

Brochure
http://www.arteliagroup.com/sites/default/files/telechargement/artelia_brochure_gb.pdf

Annual Report 2011
http://www.arteliagroup.com/sites/default/files/report_artelia_06_2012_en_2.pdf
QHSE Policy
http://www.arteliagroup.com/en/group/our-qhse-policy

Environment
http://www.arteliagroup.com/en/environment/Artelia-specialist-in-the-environment-risks-and-health

2.2 - TASK A2 - Determine the status of CWPRS vis-a-vis International bench mark

For the benchmarking comparison, it is considered that CWPRS compares best with the mandates of the two institutions in the United States: (1) the U.S. Bureau of Reclamation (USBR) and the U.S. Army Corps of Engineers (USACE). The two additional International Institutions (Deltares and Artelia) are also very important because they pursue national and international endeavors. Their examples may be very enlightening on how institutional changes can be implemented.

This benchmarking analysis has to be exercised with great caution. The objective here is not to taylor CWPRS to replicate what is being done elsewhere. The comparative analysis has to be placed in context because what works in Europe or the US may not be applicable to India. The context of this comparative analysis should be for CWPRS to have the opportunity for an open look at what is going on elsewhere. In doing so, new ideas can be considered and gradually implemented to make CWPRS increasingly in tune with engineering developments in other parts of the world.

There are 5 main remarks that I would like to make in relation to the status of CWPRS vis-à-vis other international agencies. These remarks emerged from my review of the quantity and quality of work done at CWPRS. The remarks are also substantiated by my numerous visits and research collaborations with the selected international peer institutions. They are personal observations and somewhat subjective. These observations may serve the development of new capabilities at CWPRS.

First observation: emphasis on physical modeling

My first observation is that CWPRS maintained large scale laboratory facilities very well. All peer institutions reviewed here have been subjected to tremendous pressures to downsize their physical modeling capabilities in favor of computer modeling techniques. A couple decades ago, some institutions claimed that "all" hydraulic problems could be solved with computer models. It turned out that many large hydraulic laboratories in the US and Europe closed their doors. All institutions reviewed here have been severely impacted by the transition from physical to numerical models. The USACE models at the Waterways Experiment Station have been largely downsized as a result of the much reduced costs associated with numerical models. The Waterloopkundig Laboratorium (i.e. Delft Hydraulics) in the Netherlands was critically downsized when the operations moved from Vollenhove to Delft in the mid '90's. The fact that CWPRS has been able to maintain laboratory facilities in recent years is remarkable given the international trend observed at all four other institutions. This ability to keep large scale laboratory facilities should eventually turn into the most important asset at CWPRS. This can eventually be used to gain a competitive edge over other peer institutions around the world. The availability of funds to support and maintain large laboratories is well justified in India, given the large number of structures impacted by heavy monsoon precipitation, floods and important coastal and harbour areas to be developed and protected. Contrary to other countries where the development of major infrastructure has declined in the past decades, the demands for large infrastructure for flood control, riverbank protection, coastal and harbour development is not expected to decline in India for several decades to come. The investment in large scale laboratory facilities is in my opinion a very wise investment in India. With large scale physical models, India could become highly competitive to attract international projects.

Second observation: breadth and depth of research activities

My second observation is that CWPRS is quite impressive in terms of breadth and depth of its research activities in the broad field of hydraulic and coastal engineering. There is no doubt in my mind that the institutional capabilities and competence run very deep. Many employees at CWPRS have more than 25 years of experience. This is a tremendous asset to keep qualified personnel in this applied research environment for such a long time. This compares favourably well with the peer institutions, several of which have turned their operations to young mathematical modelers with tremendous numerical modelling skills but limited engineering experience. The possibilities to keep models of certain river reaches where new construction and development plans can be gradually implemented and tested in the hydraulic models is a tremendous asset at CWPRS. The USACE used to have such large models on portions of the Mississippi River. These models were kept and maintained in hangars for future research and development. The operation and maintenance cost for these facilities and the increased cost of labor in the past decades forced a major shift towards replacing physical models with numerical models. In India, the availability of a vast resource in manpower facilitates the possibility of development of physical models. It has to be considered that the relative low cost of operation at CWPRS will likely enable the possibility of maintaining such large models for decades to come. In comparison with all peer institutions, the cost of labor has been prohibitive in the US and Europe to the extent that computer models became largely favored and viewed as more cost effective than physical models. In all developments of science and technology, it has to be understood that the exclusive use of numerical models is limited in scope and many significant advances in engineering technology do, as they did in the past, require validation with experimental capabilities. The asset of experienced engineers with skilled lab technicians can present a unique combination for continued success. The expansion of physical modelling capabilities in conjunction with computer models can lift CWPRS among the elite institutions around the world.

Third observation: massive national demand for water-related infrastructure

My third observation is that the mandate of any institution is viable as long as there is a national demand for development of water resources. The example of Delft Hydraulics is quite instructive in this regard. After the large floods and coastal problems in the 1950's, the country invested massive sums for the development of adequate water resources to protect the large populations in the Netherlands living below sea level. By the mid '90's the infrastructure had been primarily rebuilt and the flooding problems essentially solved, such that massive investments in this sector were not viewed as necessary. As the national demand dropped in the sector of water resources development, the drastic decreases in funding forced major institutional restructuration and downsizing. In times of recession, budget cuts always trigger major reductions in operations associated with detrimental reorganizations. In the United States, the pressure in recent decades has been to turn away from physical modelling and move towards lower cost computer modeling. At the same time, once the large dams in the US have been completely built, the emphasis also changed towards water quality, environmental considerations and stream restoration. There is still a great deal of research going on in America. The emphasis, however, changed from infrastructure construction and design to meet environmental needs and better water quality standards. More details on this will follow in this report. In India, the massive population has created a gigantic need for basic infrastructure. Given the monsoon precipitation and some of the record breaking precipitation levels in India, the needs for infrastructure for flood control, hydropower production, drinking water and irrigation and drainage is expected to command the development of an adequate infrastructure for water. With this tremendous and sustained need, the country will likely have to continue to develop basic engineering structures (e.g. dams, hydropower and nuclear plants, coastal protection and harbors, etc.) for decades to come. The transition to water quality, sanitary engineering, stream restoration and stream ecology may be slower in India than in other parts of the world but a gradual change in this direction needs to be gradually implemented. The change towards more environmentally-friendly research implies new opportunities for growth and the potential to expand the research activities in new areas. More details on these new areas will be provided in this report.

Fourth observation: relative isolation of CWPRS

My fourth observation is regarding the relative isolation of CWPRS in comparison with peer institutions. This seems to be partly attributed to the current travel restrictions at CWPRS. This is part of the national mandate, which only allows domestic travel. Approval for international travel currently needs to be requested from the Ministry of Water Resources. A similar policy is also enforced at the USBR where the operations with the U.S. Department of the Interior mandate work within the confines of the national boundaries. It is clear that countries in Europe have allowed the ability to work within the European Union. It is also clear that many rivers and large projects affect several countries in Europe. For instance the issues on the Rhine River involve the Netherlands, Germany, France, and Switzerland. It has to be considered that India is a large country and the Himalayas and oceans provide natural boundaries. Some activities are currently going on with neighboring countries (e.g. Bhutan, Nepal…) and some relaxation of travel restrictions for international travel would be desirable in the future.

Fifth observation: civil servant mentality at CWPRS

My fifth observation relates to the civil servant mentality that prevails at CWPRS. The baseline document mentions the lack of motivation of some employees and the lack of incentives that are provided to encourage further professional development of the workforce. The comparison with peer institutions showed that the decreased base funding and the increased pressure to compete with the outside world forced all four agencies considered to increase their productivity and performance levels. The developments in the digital age forced an increased involvement of all employees towards unprecedented productivity levels. Nowadays, government employees spending at least 50 hours a week at work is not uncommon in the US. Europeans agencies also increased productivity and managed to maintain a large number of days off work and a more family-friendly work schedule. This increase in productivity is not without setbacks. Several agencies have changed their operations to imitate the private sector, where the manpower is subject to the ups and downs of economic times. In down times, restructuration and downsizing through attrition and retirements has caused a lot of turnover and lack of continuity in the expertise of the workforce. It is often more difficult to find qualified people who stayed loyal to their employer for 25+ years. The digital age also forces a lot more research to become superficial and ephemeral, with a goal to produce something quick that may not be durable. The competition with the private sector has had a direct impact on some agencies like the Artelia, Deltares, USBR and to a lesser extent on the USACE. Some incentives to motivate the workforce may become very welcome at CWPRS. Some inspiration in this regard may be found from an increased ability to interact with International Agencies.

2.3 - TASK A3 - <u>Identify the gaps in the areas of research and the mandate of the Institute</u>

Per the TOR, the vision and mission statement for CWPRS reads as follows:

CWPRS vision is to build a World Class Centre of Excellence in hydraulic engineering research and allied areas; which is responsive to changing global scenario, and need for sustaining and enhancing excellence in providing technological solutions for optimal and safe design of water resources structures. Its mission is to:

- To meet the country's need for applied and basic research studies in water resources, power sector and coastal engineering with world-class standards.
- To develop competence in deployment of latest technologies and to undertake new areas of research to meet the future needs for development of water resources projects in the country.
- To disseminate information, skills and knowledge for capacity-building and mass awareness.

Based on the 40 presentations that I have reviewed during my two visits (25 technical presentations, 8 summary presentations, and 7 development plans), CWPRS is doing a fabulous job at covering the needs for basic and applied research in an unusually broad area of water and power. The activities are centered around traditional engineering methods for the construction of dams, river engineering projects, flood control and energy dissipation, coastal, harbors and ports, nuclear power plants, foundations and geophysical research. The methods currently used are based on sound engineering practice and many projects handled at CWPRS have a national and international perspective.

Future developments along the national mandate of the Institute will certainly continue to focus on the building of adequate infrastructure for flood control, hydropower, nuclear power, coastal and harbors, irrigation and drainage, water supply, energy dissipation, river engineering, etc. In my view, the basic organizational chart for the seven main disciplines listed in the baseline document should essentially remain unchanged in the near future. Although no major restructuration seems required, some areas will benefit from expanding their operations. In general, further developments in each discipline should expand towards the environmental aspects of hydraulic engineering. This should be done in a way to improve the quality of life for the population of India. Some of the basic needs related to water include a reduced contamination of surface waters. This require increased collaboration with the Ministry of Public Health to meet the growing demand for clean drinking water and sanitary waste disposal. The sanitary disposal includes land, air and water (or three phases: solid, liquid and gaseous). Major improvements in the quality of life in India could be gained through a gradual increase in awareness about the value of water quality. I am not suggesting sudden and drastic changes in the internal operations at CWPRS. However, the demand for basic infrastructure that stems from the river engineering operations need to be expanded to encounter water quality problems. One saying in the US is that sediment is the foremost pollutant of surface waters. The activities in sediment transport and river engineering thus bear a tremendous impact on the quality of surface waters and their treatment for drinking water. Fine sediments also have a tremendous adsorption potential and their interaction with pollutants and contaminants in surface waters present unique opportunities for growth and development at CWPRS. The development of environmentally friendly major infrastructures should, in my view, gradually become increasingly important among the priorities of CWPRS operations.

2.4 - TASK A4 – Suggest areas of expansion and upgradation both in terms of personnel, technology, infrastructure and equipments keeping 12th plan proposal in view

In keeping the 12th plan proposal in view, I wish to comment on the analysis presented in the Baseline Document (section 14. SWOT analysis) regarding the Strengths, Weaknesses, Opportunities and Threats at CWPRS. Let me comment on each of these in an itemized fashion prior to exposing my views on the future expansion at CWPRS.

2.4.1 - Strengths

- Infrastructure for physical models (land, water, testing facilities, precision workshop, etc)
- Large number of disciplines under one umbrella
- Qualified and experienced staff with specialization and continuity
- A large database on a variety of hydraulic structures being one of the oldest research institutes in the world, established in 1916.
- Broad-based clientele from public as well as private sectors, being a neutral laboratory under GoI
- UN recognition as Regional Laboratory for ESCAP region

I agree with all statements of strength expressed under this list. Perhaps the most impressive are the broad-based clientele and array of projects on national importance for the Government of India (GoI). The large infrastructure for physical modeling is impressive. CWPRS managed to maintain large laboratory facilities with equipment and personnel while most similar institutions around the world have experienced tremendous difficulties to maintain their laboratory facilities. The fact that CWPRS could keep their qualified staff and support a large display of models since 1916 definitely brings continuity. This is one of the assets of foremost importance to maintain in the future operations at CWPRS. The large number of disciplines under one umbrella is also specifically important regarding the main area of research with focus on water and power. The UN recognition is interesting, but it has to be acknowledged that the ability to carry out international projects at CWPRS is relatively awkward given some institutional difficulties to allow international travel. Under the current travel restrictions, CWPRS is probably ill-prepared to become highly competitive at the international level. At this time, the perspective for international development seems restricted. CWPRS has maintained a strong national identity so far, in the sense that the international projects seem to have been supported by the GoI rather than from International funding sources. Future active development on the international scene would require major changes in the institutional mode of operation. For instance, the desire to become very active and competitive at the international scale would require: (1) major investment in time and resources for marketing and international development; (2) increase in productivity from all staff members; (3) allowing staff members to travel abroad. This may not be viewed favorably at the national level and it is not obvious that the current level of national funding could be maintained if CWPRS were to engage in major international project development. There would need to be some compensation for the employees and staff members for their increased workload and professional commitment.

2.4.2 - Weaknesses

- Lack of international exposure
- Lack of collaboration with other institutes within the country and abroad
- No incentives for excellence
- Career progression opportunities limited
- Procedural delays in procurement and deliverables

My impression from the first visit would agree with most observations here. The lack of international exposure stems from the national mandate of the institute. Similar restrictions are also part of the daily operations at the USBR. There are severe limitations on the ability to travel internationally. USBR also does not carry out international projects. My understanding is that the international exposure cannot be easily fixed. However, the international visibility can be increased and some suggestions will be offered below.

The lack of collaboration with national institutes seems rather difficult to understand and this may be subjected to changes. Contrary to many other countries, most people in India master the English language and can take advantage of the world-wide web, email, skype, etc. to reach out and extend their contacts and learn about what is going on outside of CWPRS. It seems that there may be a lack of incentives towards excellence but there are numerous opportunities for outreach and direct collaboration with researchers at other Institutes and Universities at the national level. It is true that the current procedural delays and paperwork requirement for international travel are partly limiting the career progression of the employees.

2.4.3 - Opportunities

- Increased Demand due to fast development of hydropower potential, interlinking of rivers and development of ports and other infrastructures
- Liberalization – Global Market
- International Cooperation and Collaboration
- New Areas of Research to Meet Future Needs

The increased demand stems from the increased population and the ever increasing concerns with disaster prevention, energy needs, and limited resources. These trends are not likely to subside in the future. The opportunity for “liberalization” seems promising at first sight. However, the national demand is tremendous at this time. The concept to largely expand the operations at the international level would be interesting and are very likely to be lucrative for quite some time. CWPRS has the potential to become an international center of excellence in physical modeling in several areas including: hydraulics, rivers, hydropower and energy dissipation and coastal engineering. With relatively little marketing, the Institute could blossom in developing world-wide projects at relatively low cost. The main challenges would be to increase productivity and reduce the turnaround time. The projects could be lucrative with foreign currency. There may be a way to provide better incentives to employees for their increased performance. The possibility for gaining autonomous status for the Institute would accomplish this goal and could be beneficial. Such an enterprise may be lucrative but would likely be accompanied with setbacks regarding some of the current strengths of CWPRS. More specifically, there would likely be a lack of continuity and an increased turnover in personnel. A focus on international projects would also likely result in a gradual change towards numerical modeling and a decline in the use of physical models. However, the main set back would be the primary mission and mandate of CWPRS for national projects. In view of the possible conflict and restrictions between national and international goals, my view would be to maintain the primary focus on national priorities. The new areas to meet future needs are expanded upon under Task A5 below.

2.4.4 - Threats

- Competition with academic and similar other research institutes abroad
- Increased cost due to growing establishment charges

The real threat mentioned here is the cost. The cost of development, equipment, training, international travel and marketing, etc. Academia does not present a threat to CWPRS. To the contrary, I believe that collaboration with other academic institutions would be tremendously beneficial to CWPRS. My presentation in the new auditorium during my second visit was specifically focused on this point. My presentation was entitled "The power of collaborative research" with a specific purpose to demonstrate how collaborative research between governmental agencies and universities can lead to win-win scenarios and greatly increase the visibility and reputation of both collaborators.

2.4.5 - Suggestions for upgrading CWPRS

There are five aspects that should be considered in the future developments at CWPRS.

1. Priority on national projects
India is in dire needs for major infrastructure. CWPRS assumed the leadership so far. The GoI invested resources for large laboratories and qualified personnel. It would be a shame to lose focus from the national needs. International projects may be gradually included through perhaps some relaxation of institutional restrictions regarding international travel and possible use of external resources to upgrade facilities or support deserving employees. In terms of comparative institutions, the USBR may be the leading example of how this institute did maintain its focus on national priorities while keeping competence and a strong identity. Their involvement in international activities is rather limited.

2. Upgrading Laboratories and Computers
I view the laboratory operations as being essential to the future operations at CWPRS. Most other entities have reduced their laboratory operations because of increased costs for equipment and manpower. CWPRS has unique laboratory facilities and should build on its strength. It can become the "best" in the world in physical hydraulic modeling. With first-class laboratory facilities, the future marketing of experimental capabilities should then become self-evident. I also see the need to upgrade computer equipment. Most other companies have turned to computers to solve "all problems." The limitations of such an approach have become evident. I do not think CWPRS should turn their operation towards computer models. Many other entities around the world have done that and are quite competitive. I believe CWPRS

would lose its focus and identity in turning their operations towards a future centered around numerical models. There are unique opportunities for hybrid computer and physical modeling that could be implemented. CWPRS could gradually become at the forefront of comparisons between numerical and physical modeling in hydraulic and coastal engineering. There is nevertheless the need to upgrade the computer facilities at CWPRS. This should remain a very important priority after upgrading laboratory facilities.

3. <u>Collaborative research development</u>

To address some of the needs in capacity building, there should be an increased collaboration with other national entities in India. For instance, CWPRS could develop very fruitful collaboration with academic institutions: (1) in offering large laboratory facilities that cannot be found in universities; and (2) CWPRS should be able to recruit and host numerous graduate students who want to solve problems of national importance. As discussed during my seminar presentation on July 23, this can lead to better visibility of the large laboratory facilities. Collaboration with universities can lead to refereed publications in scientific journals since most professors are required to write significant articles. CWPRS would also gain in providing exposure of their facilities to promising young scientists and engineers. This can become a great recruitment tool for CWPRS.

CWPRS may also seek collaboration with other institutes in India dealing more specifically in the areas of hydrology (e.g. NIH), or sanitary engineering (Ministry of Public Health). These collaborations may be possible through visits of respective institutes and laboratories, workshops held at respective institutions, and perhaps foremost: collaboration on joint projects. Some of this collaboration can be found through service to professional societies. There is an urgent need to clean up surface waters, prevent raw sewerage from entering rivers, building urban collectors, building waste water treatment plants, and thrash collectors to remove floating debris. Collaborative research in those areas can reach a new dimension through more advanced research at CWPRS on river restoration, river parks, promenade and boardwalks through restored riparian areas with reconstructed wetlands, etc. There is new research on the development of floodplains for recreational purpose, green belts, riverside cultural centers, river sport areas for canoe, kayak, boating, restaurants and riverfront property development, etc. Obviously, there is no way to try to develop marinas and riverfront property management along rivers when raw sewerage floats down the river. To be successful in India, these new river restoration strategies would require the collaboration of both the Ministry of Public health and CWPRS. Without such collaboration, it is doubtful that any progress can be made. More importantly, these collaborative projects may attract people to the river and there may be a change of mentality towards keeping rivers clean and enjoyable. One specific case study should be developed for the demonstration of how surface waters can be cleaned up with proper sanitary engineering facilities, river restoration and increased visibility. This could be a very good example on how a river cleanup can improve the quality of life. The Director of CWPRS may be empowered to forge new initiatives and collaboration opportunities with other National Institutes in India. However, the feasibility of joint projects and the outreach potential of all research officers at CWPRS should be encouraged, nurtured and rewarded.

4. Increased visibility and productivity

Within a national mandate, increased visibility can be achieved through collaboration as described in the above item. There are multiple other avenues to increase visibility. Perhaps one and foremost is the ability to publish in top refereed journals. This is perhaps the highest landmark of recognition that can be achieved. CWPRS can collaborate (rather than compete) with academic institutions as previously mentioned. The ability to write joint refereed papers can merge the ability of young professors and scientists to carry out theoretical work with the innate ability of professional engineers and scientists at CWPRS to perform applied research on projects of national significance. There is a union of capabilities that can become extremely productive. This kind of collaboration with academics living overseas can be extremely productive when papers and articles can get worked on around the clock. Participation at national and international conferences is also very important to increase visibility. My seminar presented several successful examples of such collaboration between governmental and academic institutions.

CWPRS also has the unique opportunity to write very important manuals and codes of practice in the fields relative to water. These standard codes and manuals can then be taught in universities for all engineers working in certain fields. This can lead to important national reports, guidelines and definition of better national standards of practice in the engineering profession. Nowadays, a great deal of visibility can be gained through the design of web pages. The institution can share and distribute numerous manuals, codes, books, reports and material relevant to research activities. The example of the Hydrologic Engineering Center in Sacramento California should be praised for its world-wide distribution of free software for the analysis of surface runoff and river flows with sediment transport. The HEC-RAS model has been used and distributed world-wide without any attempt to make profit, but this information sharing has brought recognition far beyond the national perspective under which the operation first started.

Some marketing may be developed at CWPRS. For instance, the current web page could be improved to be more readily accessible to the information people may look for. This may include contacting people, or retrieving important reports, manuals or codes. In looking at the web page for CWPRS, it is clear that a lot more could be done and added. I have provided some links to peer institutions (USBR, USACE, Delft /Deltares and Sogreah/Artelia). These may be looked at as good examples of marketing. In general, governmental agencies are not too concerned about marketing, while this is perhaps the most important asset of consulting firms. The set of four institutions selected for the benchmarking review offers a good variety of marketing strategies that CWPRS may learn from.

Also, the name CWPRS is not quite easy to remember. I have mingled these letters for some time. Would it make sense to change the name to something more dynamic? In my interim report, I had suggested something like the "Pune Hydraulic Laboratory," or Pune Hydro Lab. I was told that the use "Pune" would not be appropriate to describe a national laboratory. From further discussion during my second visit, several possible names were discussed and there seemed to be a consensus for: National Hydraulic Research Institute in Pune, or NHRI-Pune.

Increasing productivity is always a challenge regardless of country. The fact that many people reach 25+ years of experience at CWPRS is a tremendous asset and my first trip convinced me that many employees are extremely productive and successful in the current system. Asking them what has been the secret for them would be beneficial. To see what kind of incentive they would have liked to see during their career would be beneficial for the next generation. The senior members can be very successful at mentoring junior colleagues. They can collaborate on research, share contacts and get younger members motivated. This mentoring speeds up the formation and career development of young scientists and engineers. There can be an annual banquet with recognition of the most meritorious contributions of the year. Some possibilities for short or long term training should be a way to stimulate the young and most promising employees. There can easily be a requirement for the beneficiary to work at CWPRS for several years after receiving long-term training. One of the best ways to stimulate people is to provide them with support to enable them to focus on their special capabilities. In many places, the only reward for doing good work is to have to assume additional tasks from colleagues who are incapable of getting their work done. Productive workers can be rewarded with a reduced load (instead of an increased load) to allow them time to develop and reach high levels of excellence. For instance it takes a lot of time and effort to write books, manuals and standards of practice. To allow the most productive individuals to develop their skills can yield tremendous institutional payoffs and increase the reputation of CWPRS.

Of course, the case of what to do with people who do not function well is more difficult. The work atmosphere should not be allowed to deteriorate by being forced to retain non-performing employees. In America, the solution is very simple: employees who do not perform their job well are fired and lose their jobs. My understanding is this is not possible in India. The work atmosphere should be such that all find their own reward for their work and contributions. When all employees will find satisfaction at work, the productivity can become incredible. I have two specific recommendations regarding the productivity at CWPRS:

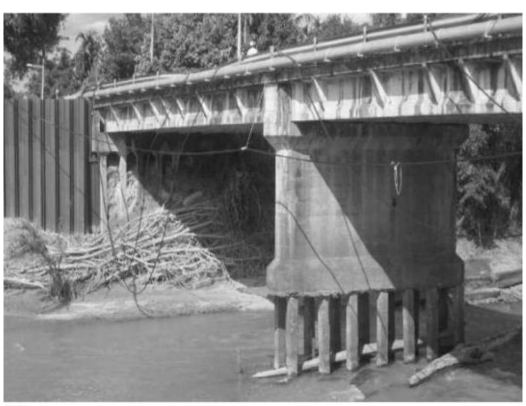
a. CWPRS should have the authority to hire their new employees. CWPRS should be actively involved in the recruitment and hiring of new employees. They should proactively look into recent graduates from engineering schools in India and abroad.
b. CWPRS should have the authority to dismiss non-performing employees from their functions. The increased responsibility of CWPRS engineers and scientists in the design of large water-related infrastructure for public safety has to be recognized. There is an unprecedented demand to design safe infrastructure like nuclear and thermal power plants, dams and pipelines against the devastating

forces of tsunamis, earthquakes, extreme floods, etc. There is no room at CWPRS for people who do not want to reach the highest possible standards of performance and professional ethics.

5. <u>New water research focus on eco-hydraulic engineering</u>

As much as CWPRS has always aimed at public safety in their design of large infrastructure, a new focus area should center around the development of better quality of life. This can be coined in a broader perspective of environmental engineering. For instance, I have noticed a need to clean up trash and develop ways to improve the quality of life with better land, better air and better water. The needs for cleaner surface waters cannot be overemphasized. The need to remove trash from surface waters should be a priority. Let me give an example from Malaysia in the photo above. The effort to remove trash from surface waters and the need for clear waters is illustrated. It would be short sighted to think that research on this should not be undertaken because it should be undertaken in a different branch of government. An integrated management of water resources, or an integrated river basin management approach could be developed at CWPRS. There is an opportunity for CWPRS to assume a leadership role in reaching out to other public institutes and in developing a proper integrated management strategy. The integration of the needs for clean drinking water, sanitary sewers and waste water treatment plants can be integrated with an effort to reduce surface water pollution and contamination and lead to river restoration and the development of water parks and green river corridors can greatly improve the quality of life in India.

Another area of prospective research deals with gravel mining in rivers. Some companies are allowed to excavate sand and gravels from rivers to produce construction material for civil engineering works. In some cases, the result of excessive gravel mining has been to lower the river bed to the extent that engineering structures become vulnerable. The example shown here illustrates the excessive degradation of the river bed which exposes the foundation of bridges and undermines the bridge piers. Similar problems have been encountered with the inability to feed irrigation canals by gravity and the need to build pumping stations as well as major water salinity problems that can be experienced near coastal areas. These are examples of research areas that belong to the broad class of eco-hydraulic engineering.



(b)

2.5 - TASK A5 - Identify new areas of research keeping in view the National and International trends

New research areas in eco-hydraulic engineering have been developed in the US and in Europe in the past half century. The improvement of water quality has also gained tremendously in some Asian countries (e.g. South Korea, Japan, Malaysia and others). For instance, the case of the Four Major River Restoration project in South Korea should captivate the attention of what could be done in India. I would favourably view the possibilities for integrated river basin management by combining developments of sanitary engineering through sewage collectors and waste water treatment plants in urban areas, the treatment of chemical contamination in industrial areas, gravel mining in rivers, mine wastes and acid mine drainage, etc. In urban areas, the concept of river restoration has been very popular in the US and in Asia (particularly in South Korea). It may be worth mention that South Korean Government formed a new Ministry of River Restoration in view of the growing importance of river restoration programs. There is also an increasing effort to remove trash from rivers with "rubbish dams" in Malaysia. A major transformation is taking place to bring the populations closer to rivers via river corridors, stream restoration, river rehabilitation design, mangrove and wetland restoration, riverfront developments and ecological parks.

My recommendation for the gradual development of new research areas that would benefit the population of India would be along the following lines.

- The first phase of development should be for basic infrastructure. This is currently what is being done in India with basic flood control, water supply and energy through hydropower, thermal and nuclear power. This also includes the analysis of extreme events with devastating consequences such as floods, earthquakes and tsunamis. By the way, there is currently no research facility for the analysis of tsunamis in India.

- The second phase should provide direct benefits to quality of life. The emphasis is on direct implication on the quality of human life. Gradual improvements in the quality of life are warranted through efforts and developments in the environmental areas. For instance, some improvements could be in the development of new eco-hydraulic approach with the broad objective of cleaning surface waters. This can be achieved by expanding the traditional sanitary engineering to reduce the contamination and pollution of surface waters with the treatment of chemical contamination in industrial areas, mine wastes and acid mine drainage, toxic waste and explosives from specific sites. There is a need for major efforts in the design of environmentally-friendly hydraulic structures for flood control, detention and storage, water supply, irrigation needs, point source pollution, clean surface waters, sediment management, water decontamination, gravel mining, irrigation canal intakes and water supply to farming areas, stream restoration and rehabilitation, etc.

- A third phase would provide indirect benefit to the population of India. The emphasis here is on indirect implication on the quality of human life. The effort may be on water quality in coastal areas, mangroves and wetlands, oil spills, clean-ups, etc. Along rivers, developments could be on non-point source pollution and an integrated river basin management strategy for nitrates and phosphates, fertilizers and pesticides, algae blooms, control of invasive species, infestations of insects, virus bearing mosquitoes and flies, microbials and pharmaceuticals, etc. A new eco-hydraulic dimension involving river restoration, water parks, and developments in river recreation should be considered here. This may possibly extend to climate change, sea level rise, carbon footprint, global warming, etc.

- A fourth phase would enhance the quality of life in general. Further development can be carried out in providing and developing aquatic habitat for fisheries and waterfowl and migratory species, fish passage and aquatic habitat, endangered species, reconstructed wetlands, mangroves, port and harbour fisheries, stream ecology, riverfront properties, hydro-tourism, etc.

A compendium of activities at the peer institutions is summarized below in order to give ideas of what type of activities have been undertaken at the four selected agencies: USBR, USACE, Deltares and Artelia. One has to be careful in considering that the economical and legislative structure in the US and Europe differ greatly from the current situation in India. It has to be kept in mind that India is one of the most densely populated areas in the world.

2.5.1 - Environmental - USBR

Environmental Impact Assessment Studies

We conduct environmental impact assessment studies associated with Reclamation's and other Federal agencies' compliance requirements under the National Environmental Policy Act, Endangered Species Act, Clean Water Act, and other legislation. Our staff has extensive experience in evaluating project effects on anadromous and resident fisheries, raptors, waterfowl, and neotropical migrant songbirds, wetlands and riparian habitats, and desert ecosystems.

Analytical Chemistry & Environmental Research

Our group uses state of the art technologies to offer better and lower cost analyses of water, soil, plant and animal tissue, and other related environmental samples. This information helps Reclamation better understand, protect, and enhance water quality and other environmental conditions.

Aquatic Site Pest Management

Our group develops and coordinates *Integrated Pest Management* (IPM) techniques for use with water transport and storage systems. These studies assist in operational efficiency of these systems as well as help reduce adverse environmental impacts, such as those caused by noxious weeds and pests.

Reservoir Monitoring & Research

Reservoir research is an important component of properly operating and managing many of Reclamation's 350 reservoirs and associated water systems. Our ongoing research lends itself to the protection and improvement of reservoir water quality as well as related environmental, recreational, and fishery values.

Riparian & Wetland Studies

Our riparian and wetland research combines numerous scientific and engineering disciplines to help understand and manage natural riparian and wetland ecosystems.

Water Quality Monitoring & Improvement

A sound understanding of the ecology of streams, rivers, lakes, and reservoirs is necessary to optimize water system operation for the protection of aquatic environments and to support the multiple resource values of Reclamation projects. Our ecological research in this area involves both natural and regulated systems and is studied in both field and laboratory settings.

2.5.2 - Environmental - USACE

1. Automated Performance Monitoring of Dams

2. Environmental and Munitions
   There are four divisions in the EM CX:
   - Environmental Engineering and Geology Division, CEHNC-CX-EG
   - Environmental Compliance and Management Division, CEHNC-CX-EC
   - Environmental Sciences Division, CEHNC-CX-ES
   - Military Munitions Division, CEHNC-CX-MM

3. Hydrologic Engineering Center
   Exists to support the Corps Civil Works water resources management responsibilities by increasing the Corps technical capability in hydrologic engineering and water resources planning and management.
   Major products are technical methods documents, computer software and user's manuals, and technical assistance.

4. Institute for Water Resources
   The IWR provides the following services: studying and evaluating water resources policy issues; conducting national-scope studies on various aspects of water resources development; examining potential new civil works missions; performing program analysis and evaluation studies; R&D of new techniques to address economic, social, institutional, and environmental issues; training and technical assistance in the use of innovative formulation and evaluation approaches; and, developing and maintaining navigation planning data bases and models.

Environmental Program

- Brownfields – Urban Waters Program
- Environmental Advisory Board
- Environmental Operating Principles
- Environmental Quality
- Estuary Restoration
- Formerly Used Defense Sites
- Formerly Utilized Sites Remedial Action Program (FUSRAP)
- Military Munitions Support Services
- Superfund
- Support for Others
- Technical Project Planning

2.5.3 - Environmental - Deltares

Ecology
- Integrated ecosystem analyses
- Ecosystem services
- Eco-toxicology
- Eco-engineering
- Eco-hydrology

Integrated water resources management
- Ecosystem services and environmental flows
- Environmental assessments
- Soil and water conservation
- Renewable energy

Operational warning and management
- Water quality forecasting
- Water quality information systems
- Water information systems

Urban Land and Water Management
- Land and water and the quality of the urban environment

Water and soil quality
- Soil and groundwater quality
- Sediment and river basin quality

Intake and outfall systems
- Sedimentation
- Water quality and ecology

Facilities :
- Chemical water quality laboratory
- In-situ analysis of sediment and water quality
- Laboratory for microbial diversity

2.5.4 - Environmental - Artelia

Environmental and Social Impact Assessment

- providing information on the environmental and social consequences of planned activities and taking suitable measures to promote sustainable development.
- widely varying scopes and types, including major energy and port infrastructure, industrial extraction or production facilities and development programmes.
- handles all environmental procedures, including carrying out initial consultations, field investigations and impact assessments, preparing and implementing environmental and social plans, obtaining environmental permits from national authorities, validating projects with funding bodies followed by the application of environmental measures.

Environmental Audits

- performs assessments to pinpoint any compliance problems, weaknesses in management systems or areas exposed to risks, drawing on its expertise to audit the facilities in question, whether the requirements relate to air/water/soil pollution, waste, or social or organisational issues.
- these audits provide practical solutions for improving a site or facility's environmental management plan, ensuring compliance with regulations or reducing its carbon footprint

Environmental Engineering

- the application of sustainable solutions to protect, collect, store, treat, recycle and rehabilitate.

Environmental Due Diligence

- pre-purchase expert appraisals enabling investors to base their judgements on precise information concerning a site's environmental liabilities and helping them find their way through liability regulations that are becoming increasingly complex when it comes to the environment, health and safety.

Environmental Consultancy

- organising environmental compliance training, arranging public consultation or project presentation meetings, assisting with crisis management and helping to draw up environmental assessments and reports.

Sustainable Development Consultancy

- provides clients and in-house teams with up-to-date information, advice and assistance during project management and engineering assignments.

- ensures that a sustainable development approach is adopted from project feasibility study stage through to the commissioning of a building or infrastructure and if possible to its deconstruction.

Solid Waste

- help clients select processes and implement the developments that most closely match their present and future needs (reduction at source, collection service, waste collection centres, sorting centres, reuse for energy through incineration and methanisation, composting, recycling, landfill, ultimate waste storage site, etc.)

Industrial Site Risk Management

- assess the client's vulnerability to extreme events and the impact of climate change, define adaptation strategies and ensure the safety of their critical equipment and facilities, taking "domino effects" into consideration.
- also participates in drawing up risk assessment and management plans.

Polluted Soil and Groundwater Remediation

- conducts environmental and quantitative health risk assessments, proposes monitoring, containment and remediation strategies and implements industrial site rehabilitation scenarios.

Floods and Natural Hazards

- detailed mathematical modelling of floods in urban areas.
- designed innumerable protection schemes.
- prevention and evaluation of the vulnerability of public and private property, and implementing structural and non-structural risk-reduction measures.
- flood-risk prevention and disaster contingency plans and helps to set up flood warning, flood forecasting, alarm and disaster management systems as well as resilience measures in urban areas.

Risk and Hazard Assessments

- safety studies of hydraulic structures.
- perform monitoring on embankments and dams.
- Numerous hydrological and dam break wave studies have also been performed in order to prevent risks related to managing these major structures.

2.6 - TASK A6 – To identify training programmes in relevant areas

My personal viewpoint offers an international perspective of what is currently being done elsewhere and some good ideas may be useful. Nevertheless, the needs for training can be viewed both for reaching a higher level of competence in the current research areas, develop new areas of activities, or also may be viewed as a way to stimulate development and growth and reward the most deserving employees of CWPRS.

Three levels of training needs should be considered:
The first level of training should be long-term training for junior employees. It should focus on technical areas of expertise under development or improvement. It would be beneficial to look closely into the recruitment process and see if the leadership team can actively be involved in seeking young graduates from universities in India and abroad in the areas of sought expertise. For instance, graduates from universities with large laboratories in hydraulics, river engineering and coastal engineering would be valuable persons to hire at CWPRS. If no recent graduate can be found or recruited, it would be well worth sending some of the most talented and deserving young engineers and scientists for training abroad. Some of the knowledge gained overseas can be tremendously beneficial. At the M.S. level, the trainee can learn the state-of-the-art on a given subject. The M.S. level training can be done either with thesis (normally takes 2 years) or without thesis (normally 1 ½ year). The advantage of a thesis is to allow the student to learn to write a long document in English. Training for a Ph.D. degree is also possible but it requires about 3-3.5 years to complete. It is understood here that given the shorter time commitment, it may be impracticable to send people abroad for Ph.D. studies, and it may be more appropriate to send people abroad for M.S. degrees. Nevertheless, let me emphasize the value of training for Ph.D. degrees. In the United States for instance, the trainee will learn from a broad spectrum of classes in the water areas and will develop skills for computer modeling and in some cases in physical modeling. The other big advantage is in the ability to write comprehensive reports (a dissertation) on a given topic. The candidates can search the literature, use the latest computer skills, take a new subject for study and explore the new area in a comprehensive manner with developing the ability to write a long document. In my opinion, the possibility to invite young graduates for a visit and possible job interview can save tremendous resources to see if the candidate's research fits well within the mission of CWPRS. For example, the USBR has been very successful at recruiting top graduates with Ph.D.'s from the best schools in fluid mechanics around the US. The advantage has been to recruit young and talented individuals. Personally, in working with international institutes similar to CWPRS, I found interesting to note that institutes that approached me for a visit before sending students to work with me were able to define research projects for the trainees that were directly linked to their research activities. In very general terms, computer needs could be fulfilled by recruiting native students who studied abroad in the US. Their ability to run computer models and set up computer networks should be beneficial to CWPRS. There should also be some long-term US training definitely in the area of river restoration, and possibly in areas of coastal engineering, GIS and computer modeling. Long-term training should be linked with a commitment to stay with CWPRS upon completion of the training requirement.

The second type of training should be termed short-term training for specialized subjects. It is quite effective to invite an expert to give a short course for several weeks or a few months. The cost of inviting an expert is usually much less than sending trainees abroad. The possibilities for junior employees can be beneficial in terms of knowledge gained from the short-term training experience. The opportunity can also be very welcome for mid-career and senior employees who want to see how research is done elsewhere. It is often very useful for the trainee to give a seminar presentation on their own research activities. Foreign seminars always require tremendous energy levels from the trainees, particularly while traveling overseas with jet lag and demanding travel schedules. This possibility is excellent to increase the visibility of your own institute and research. There should be some long-term plan for regular or periodical short-term visits with international experts. This could include a combination of opportunities for senior researchers CWPRS to exchange at the global scale as well as the possibility to invite international experts on a long-term basis for sabbaticals, extended stays, short courses or for periodical appointments as reviewers and advisory board members. Some administrators also enjoy developing international memoranda of understanding (IMOU). I am not particularly fond of such initiatives since they require a lot of time for paperwork. In many instances, the turnover in administrative personnel becomes a hindering factor. IMOU’s can nevertheless become useful when there are research collaborators to follow up after the paperwork is in place. Long friendships and exceptional collaboration leading to great papers, manuals and projects can greatly enhance the visibility and reputation of CWPRS and prove to be most effective on the long-term. Administrators or team leaders should get involved in national and international committees. Such activities require a serious time commitment which is most often not remunerated. However, the ability to see what is going on elsewhere expands the horizons and the ability explore new ways of doing things. This opportunity could be brought up as a reward for excellent work and should include visits to some large laboratories around the world, short-term training from leading experts invited at CWPRS, visits of particular laboratories and foreign peer institutions, some short-term training for short courses in the U.S. or Europe. The training activities should require additional tasks from the trainees, such as the requirement to present a paper at a Conference, or at the visiting institution. Possibly, a link should be established with someone of the visited institution. This can provide essential information on the timing of the visit, persons to contact and other activities going on at the time of the visit. Something important during the short-term visits is the need to have an interpreter to enable communication and facilitate the travel schedule. I have seen too many visiting groups at CSU totally unprepared and unable to communicate, which gives us a lasting impression on how disorganized they really are.

The third type of training should be for senior research officers and joint directors. Short visits (usually less than one week) are deemed appropriate to visit international institutes and universities. These trips may be for presentation at a conference, participation in an international forum, service on a televised international panel... These visits (also called jet-lag tours) can provide useful information on active research programs in foreign countries. More information on the training programs will be detailed in section 4 - Task C of this report.

3 - TASK B: STRENGTHENING OF CWPRS WITH SOFTWARE/EQUIPMENT IN ITS AREAS OF ACTIVITIES

1. **To benchmark the various infrastructure of the Institute and technological upgradation of different laboratories of CWPRS.**
2. **Draw up specifications for the state of art equipment alongwith cost.**
3. **Identify potential institutions for imparting trainings on the identified equipments**
4. **Identify the potential suppliers of the equipments globally**
5. **Identify proprietary equipments, if any**

This task is focused on the equipment needs for CWPRS. All five sub-tasks are combined together in this section. The overall infrastructure is first considered and followed by the laboratory and field equipment needs in terms of hardware and software.

3.1 - Need to renovate the existing buildings

In terms of overall infrastructure, the buildings and large scale equipment are first considered. The overall research infrastructure at CWPRS used to benefit from infrastructure support for equipment and training from the UNDP from 1970-1998. Per the detailed list in Table 3.1, the UNDP funded ~ $21 million USD for the upkeep of the facilities and training, and this primarily from 1972 and 1998. For instance the last significant UNDP investment into the infrastructure of CWPRS was about $2 million USD from 1990-1998. Since 1998, it has been 14 years since a major investment in equipment has been made at CWPRS and this has a detrimental impact. The working offices of most researchers are equipped with furniture that seems to date from the colonial times, and are far from world-class levels.

Director Gupta and his team have somehow managed to maintain the facilities operational, although the vast majority of research buildings and laboratories is clearly aging. For instance, some very large buildings near the entrance have been left for commemoration. These buildings have not been used for decades, perhaps half a century, and in some cases roofs are caving in and large trees have established permanent roots. This is not in line with the standards for a world-class institute. Dr. Gupta mentioned that he already has a plan to demolish these obsolete facilities. My point here is that the entire building infrastructure has been neglected not for a year or two, but for several decades. There is an urgent need for major capital investment to meet the challenges of the 21st Century. It is worth mention that the current leadership team at CWPRS deserves the credit for two recent buildings: (1) a new auditorium in which I was apparently the first speaker; and (2) a new large coastal engineering laboratory completed about 2 years ago. Dr. Gupta and the leadership team has prepared proposal for the renovation of twelve buildings in disrepair and the list given below must be given top priority. The itemized building renovation request found below in Table 3.2 is for a total of **~ 10 cr** for the renovations of the existing buildings.

Table 3.1 List of UNDP/UNESCO Assistance received by CWPRS

UNDP/UNESCO ASSISTANCE RECEIVED BY CWPRS (IN US $)

Name of the project	Period	Equipments	Consultants	Training	Admin. support personnel	Misc.	Total
SMT	1950-53	80,000	-	-	-	-	80,000
PE	1956-57	16,000	-	-	-	-	16,000
IND/71/055 CAV	1964-68	441,000	30,000	16,000	-	4,000	491,000
IND/71/601 CERC & DOHI	1972-81	2,848,123	431,861	224,957	88,530	71,864	3,715,335
IND/73/043 Extn. CERC	1977-84	1,203,439	141,499	248,200	2,214	20,632	1,615,984
IND/75/020 Extn. HIC	1977-84	2,176,865	166,652	241,512	12,886	47,979	2,645,894
IND/73/041 AESD	1977-84	1,709,806	238,411	267,333	22,794	39,059	2,277,403
IND/84/024 Fellowship in W.R.	1985	-	-	243,715	-	-	243,715
IND/73/042 HM (Phase I)	1977-81	1,090,078	125,742	104,493	13,273	25,834	1,359,420
IND/85/069 HM (Phase II)	1985-88	624,619	84,843	15,000	1,850	8,538	734,850
IND/81/038 HSRC	1982-88	3,294,023	533,072	567,257	57,153	62,671	4,514,176
IND/82/036 WAPIS	1982-88	655,745	45,951	99,749	-	6,448	807,893
IND/90/008 AOICS	1990-98	271,421	299,182	193,749	-	9,129	773,481
IND/90/038 MMCFOH	1990-97	1,108,062	298,289	662,407	-	14,769	2,083,527
		15,533,181	2,425,502	2,894,372	198,700	306,923	21,358,678

FOOT NOTE

SMT - SHIP MODEL TESTING
PE - PHOTOELASTIC LABORATORY
CAV - CAVITATION RESEARCH CENTRE
CERC - COASTAL ENGINEERING RESEARCH CENTRE
DOHI - DEVELOPMENT OF HYDRAULIC INSTRUMENTATION
HIC - HYDRAULIC INSTRUMENTATION CENTRE
AESD - APPLIED EARTH SCIENCES DIVISION
HM - HYDROMECHANICS OF PUMPS
HSRC - HYDRAULIC STRUCTURES RESEARCH CENTRE
WAPIS - WATER AND POWER INFORMATION SYSTEM
AOICS - AUTOMATED OPERATION OF IRRIGATION CANAL SYSTEM
MMCFOH - MATHEMATICAL MODELLING CENTRE FOR FLUVIAL AND OCEAN HYDROMECHANICS

Table 3.2 List of buildings in need for renovation

Name of the buildings to be renovated	Approximate Plinth Area in sqm	Tentative cost in Rs. (lakh)
Office-cum-laboratory building (OCL) - Three storied (constructed around 1965)	2400	360.00
(DOHI) - Two storied (constructed around 1969)	2200	70.00
Coastal Engineering and Research Centre (CERC) - Two storied (constructed around 1971)	630	65.00
Coastal Data Centre (CDC) - Two storied (constructed around 2000)	450	10.00
Ship Hydrodynamics (SH) - Single storied (constructed around 1962)	3000	60.00
Hydromechanics (HM) - Single storird (constructed around 1957)	1500	75.00
Cavitation -Three storied (constructed around 1961)	250	50.00
Improvement of Canal Control (ICC) - Single storied (constructed around 2000)	440	5.00
Central Work Shop (WS) - Single storied (constructed around 1949)	1125	50.00
Central Store - Single storied (constructed around 1950)	2200	45.00
Sub-division Office of Assistant Executive Engineer (Civil) (AEE- Civil) - Single storied (constructed around 1950)	200	50.00
Instrumentation Workshop - Single storied (constructed around 1963)	1600	35.00
	Sub-total	875.00 **~ 10 cr**

3.2 - Need to build large facilities for the 21st Century

In terms of large facilities, it is viewed that the following large facilities (~ 25cr) are needed to meet the challenges of the 21st Century in water-related research:

- A new flume for tsunami research (10 cr) - A tsunami flume could be built in refurbishing existing facilities. The new tsunami flume could be designed to maintain a dual purpose for single waves of random wave generators for breakwater studies.
- Eco-hydraulic research facility (8 cr) - A large eco-hydraulic facility for the interaction between rivers and the ecosystems. This facility can be used for the analysis of river restoration, urban flooding, sediment contamination, mining impact, fluvial geomorphology, riparian habitat, water quality modeling, and interaction with the aquatic ecosystems.
- Hydro-vibration research facilities (4 cr) - A large vibration table (~ 3m x 6m) should be built for the analysis of the effects of earthquakes and vibrations on soils and hydraulic structures. This would be important for the analysis of liquefaction, dynamic stability of dams and other hydraulic structures during earthquakes.
- Thermal laboratory facilities (3 cr) - This will enable better understanding and design of cooling systems for thermal and nuclear power plants. This includes the experimental analysis of diffusion and dispersion as well as thermal stratification and salinity intrusion problems.

3.3 - Need for new equipment and new computing capabilities

In general, other laboratories around the world have replaced propeller-type velocity measuring devices with electronic equipment, e.g. Acoustic Doppler Velocimeters (e.g. ADCP, ADV…) and electromagnetic devices (e.g. Marsh McBirney…). Other distributed systems like GIS, PIV, multi-spectral scanners, are also commonly equipped with wireless SCADA data collection systems. Most laboratories have developed advanced computer modeling capabilities, and this is an area where CWPRS could make considerable progress. Many laboratories around the world have completely shifted their operations from physical to numerical models. There is no doubt in my mind that the large physical models represent a trade mark of excellence and with a modest increase in computer modeling capabilities, CWPRS is likely to become the best equipped laboratory in the world. It is difficult to assess the exact proportion of physical/field modeling activity in comparison with numerical modeling activities. My recommendation is that the physical and field measurement capabilities should remain far greater than the numerical modeling, which can be done by competitors. With an approximate ratio of numerical to physical modeling around 25%, CWPRS would definitely become highly competitive.

A detailed list of needed equipment (hardware and software) has been established for each of the seven disciplines at CWPRS. The equipment lists include the type, the supplier and cost in an itemized fashion. The lists are prioritized with the most important item on top of the list. The training needs for the use of the equipment are reported separately in the training list of Task C. It should be mentioned that these lists have been presented, reviewed and discussed during my second visit from July 23-27. All the listed equipment items are justified and are recommended for purchase. My recommendation is to give a top priority to laboratory equipment. It is only by keeping the laboratories equipped with the latest and best apparatus that CWPRS can retain a competitive edge.

There is also no doubt that a substantial upgradation of the computer equipment in terms of hardware, software and training would add a tremendous dimension to the capabilities of CWPRS. In terms of computer software, the availability of freeware has increased tremendously in the United States. Some vendors still request considerable sums of money for “executables” codes rather than “source” codes. It is viewed that the training of young research officers may be more valuable than the purchase of commercial software. Graduate students can find several good models with source codes freely available, or at very low cost, from numerous universities and research agencies in the United States. The availability of source codes is a tremendous asset in allowing the adaptability to different conditions by programming new algorithms that are best suited to the problems and conditions found in India. The general saying that the modeler is at least as valuable as the software prevails in hydraulic engineering. It should be added that commercial software for Computational Fluid Dynamics (e.g. Flow-3D or Fluent) are highly recommended. The Mike models tend to be expensive and they are based on technology developed several decades ago. A new generation of powerful river engineering models is becoming available and several of them are free. It can be viewed that the purchase of executables may be viable on the short term. However, to become a first-class research institute, the development of some new models in river or coastal engineering should become very desirable. The leadership in the coastal engineering with MORMOT and NAVIGA should serve as a very good example for all disciplines. Continued development of these two software packages and testing with laboratory and field measurements should be given priority. A lot can also be achieved with free software programs like HEC-RAS, MODSIM and CASC-2D and TREX. Finally it is viewed that CWPRS would gain tremendous benefits from hiring graduate engineering and scientists from IIT or from graduate students who studied abroad, particularly in the United States and in Europe.

The issue of proprietary equipment and software has been raised and seems to be a nagging problem that increases the cost of projects and operations. Well, I can say that it is a problem that is shared with all peer institutions around the world. It has to be understood that the reason some software is proprietary is to offset the real cost of putting this piece of equipment or software on the market in the first place. One important factor is that like all other peer institutions, CWPRS cannot be all things to all people. CWPRS should prioritize their needs. Each discipline has to make practical recommendations and decide which pieces of equipment/software are absolutely essential to their operations and discard those that are not worthy of purchasing. I have started this process during my two visits in which the first step is to find out the equipment needs for each discipline. The next step is that a fixed budget will not allow you to purchase everything. Some real thinking is then done to determine what is most important to have and drop the rest. In a large and resourceful Institute like CWPRS, there can be many ways to be very creative at developing new tools and techniques that will reduce the dependency on proprietary software and hardware. One effective way to cope with these costs is to distribute the cost of proprietary equipment/software over several projects. In some cases, some expensive costs for proprietary software can be avoided. For instance, the DHI products are not found to be very useful in the US because many people have developed equivalent and better performing software packages for a fraction of the cost. In many cases, software can be found for free and are available on the web. In some cases, simple collaboration with universities has been a tremendous way to reduce the cost of proprietary software. For instance, in my own research group at CSU, we have developed CASC2D and TREX. We leave the material from past research on the web and accessible to all, and this including the source code. As a result, there are several countries now sending students for long term training with us to learn how to use my software. These individuals earn a degree in taking part to the development of the software. In return, they bring this knowledge and freeware back home for the development of water resources in their own countries. This is one aspect of collaboration that I discussed in my seminar at CWPRS on "The Power of Collaborative Research." One final consideration is also that world-class institutes tend to develop their own products, equipment and software. Since CWPRS is developing expertise in certain areas, they could also potentially market some of their own products and get some return for the equipment and software that is developed in-house (e.g. NAVIGA, MORMOT, and flow meters…).

A summary of the equipment needs for each discipline is presented here. The details of each list can be found in Appendix C. The following list itemizes the needs and an estimated cost of 16 cr would meet the current equipment needs. These new laboratory equipment and large facilities will support substantial improvement in the design of better hydraulic structures and power plants (nuclear, thermal and hydroelectric) against tsunamis, earthquakes, and very large floods. In some cases, the requests may exceed the available funding and further discussion on setting priorities for each discipline will be required.

Summary of Equipment Needs

River Engineering	2 cr
River and Reservoir Systems Modelling	2 cr
Reservoirs and Appurtenant Structures	2 cr
Coastal and Offshore Engineering	4 cr
Foundations and Structures	1.5 cr
Applied Earth Sciences	1.5 cr
Instrumentation, Calibration and Testing Services	3 cr
TOTAL	16 cr

4 - TASK C: Training of CWPRS personnel

1. Identify specialized subject areas vis-à-vis Institutions/organization abroad for training of officials and detail the training course needs.
2. Assist CWPRS in corresponding with institutes for taking their consent for specialized trainings.
3. Draw up implementation schedule for training of personnel in national and international institutes over a period of 5 years during the 12th Plan period (2012-2017) including financial implications.
4. Suggest the international experts who may be invited to impart training at CWPRS in the identified specialized subject areas.

4.1 - Task C1 - Identify specialized subject areas vis-à-vis Institutions/organization abroad for training of officials and detail the training course needs.

Three types of training are being considered, per the interim report: (1) long-term training; (2) short term training; and (3) short visits. A detailed list of training needs has been formulated for each discipline. These lists are presented for each discipline in the following combined format. These lists have been reviewed and discussed during my 2nd visit from July 23-27. All requests are reasonable and subject to approval by the Director of CWPRS.

In reviewing the needs for each discipline in terms of long-term and short-term training, it is my recommendation that the following areas should be given higher priority:

- Long-term training on 2-D modeling of rivers and sedimentation. Short-term training on river restoration and stream rehabilitation. These could be combined.
- Long-term training on distributed modeling (GIS-based) of surface runoff and urban flashfloods, and modeling of dam-break and reservoir silting/sluicing.
- Long-term training on CFD modeling with Fluent or FLOW-3D. Training on the use of PIV (this could be short-term training). Modeling in 2-D and 3-D of sediment transport processes may be a good subject for advanced degrees in engineering.
- Short-term training on tsunami research, environmental coastal processes, mangrove and wetlands. Long/short-term training on modeling of thermal advection and diffusion and mixing processes from manifolds and other hydraulic structures in relation to nuclear and thermal power plants.
- Long-term training on liquefaction, vibrations and earthquake engineering. Also on the hydromechanics interaction between fluid-induced vibrations and metals (pipes, gates, etc.)
- Short-term training on the use of geophysical methods to determine the properties of concrete (density, porosity, cracking, etc.) to retrofit aging hydraulic infrastructure.
- Short-term training on cavitation, hydromachinery, acoustic and electromagnetic velocimetry.

Short visits would be valuable for the leadership team comprised of the Director and Joint Directors and perhaps selected Chief Research Officers.

Short visits would be beneficial in the following areas:

- Coastal and Hydraulics Laboratory and the Environmental Laboratory at the Engineering Research development Center in Vicksburg, MS, USA.
- A visit of the Four Major River Restoration Project in South Korea.
- River and Sedimentation research facilities in China at Tsinghua University, and the Wuhan Hydraulic Institute in China.
- Energy dissipation facilities at the ETHZ in Zurich, Switzerland.
- The Disaster Prevention Research Institute in Kyoto, Japan.

4.2 - Task C2 - Assist CWPRS in corresponding with institutes for taking their consent for specialized trainings.

The leadership team at CWPRS speaks excellent English and they can certainly make their own arrangements. I will gladly share point of contacts with Director Gupta once training requests have been approved.

4.3 - Task C3 - Draw up implementation schedule for training of personnel in national and international institutes over a period of 5 years during the 12th Plan period (2012-2017) including financial implications.

The proposed schedule would be to start the entire long-term training program as early as possible. Perhaps ten research officers could be sent off for a three-year long-term training starting during year 1 or year 2. There could be five short-term research training per year for a period of a few months for each year of the 5-year plan. The total of 15 research officers sent to long-term and short-term training corresponds to a total of 45 active training years for CWPRS. Additionally, the five visits outlined under task C1 could be planned at a rate of one per year.

4.4 - Task C4 - Suggest the international experts who may be invited to impart training at CWPRS in the identified specialized subject areas.

Numerous experts could be invited to CWPRS for training. These should be invitations for one week to provide lectures and training on the selected subjects. There could be hands-on learning when dealing with new equipment or computer models. It seems that some experts could be invited here after the purchase of major pieces of equipment. In the case of computer modeling, perhaps it would be preferable to first build high tech classroom facilities for the training. Finally, there is a tremendous opportunity that will present itself in 2016. It will be the centennial of CWPRS. The possibility to invite seven (one for each discipline) International keynote speakers for an international conference should be considered. These keynote speakers may be asked to provide a one day short course on their respective disciplines.

Each discipline of CWPRS presented a training plan and a detailed list is found in Appendix D. I have reviewed and discussed all plans during the week of July 23-27. I endorse the following request and my own recommendation on the training requirements for each discipline is summarized in the following table. In some cases, the requests may exceed the available funding and further discussion on setting priorities for each discipline will be required.

Summary of Training Needs

River Engineering	2 cr
River and Reservoir Systems Modelling	2 cr
Reservoirs and Appurtenant Structures	2 cr
Coastal and Offshore Engineering	1 cr
Foundations and Structures	2 cr
Applied Earth Sciences	2 cr
Instrumentation, Calib. and Testing Services	3 cr
TOTAL	14 cr

5 - CWPRS - A WORLD-CLASS RESEARCH INSTITUTE

This part of the report focuses on identifying the gaps to make CWPRS a world-class institute. I would like to share my vision and propose a five year plan for CWPRS to become a renowned world-class institute. I will first discuss the gaps and then propose a five-year plan.

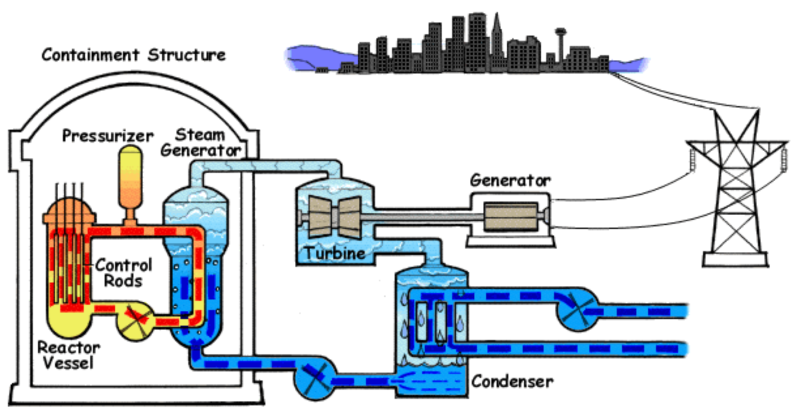
5.1 - Gaps with world-class status

CWPRS has traditionally excelled in several area of national importance. To name a few areas of traditional expertise, let me include: the development of hydropower, flood control, river engineering, sediment management, coastal engineering, energy dissipation, water supply and irrigation, earthquake engineering, cavitation and vibration technology. CWPRS has maintained large laboratories for conducting research in those areas of expertise.

5.1.1 - Emerging opportunities

In recent decades, new research areas have emerged and present new challenges for the development of water resources in India. The following list includes emerging water-related areas of national and international perspective. They all present new opportunities for research growth and a development of a better water-related infrastructure for the benefit of living populations:

- Demographic expansion - the population of India has increased from 1.02 billion in 2001 to 1.21 billion people in 2012. This represents a 20% increase in the demand for water supply, food from irrigated agriculture, reservoir operations for multi-purpose dams, etc.



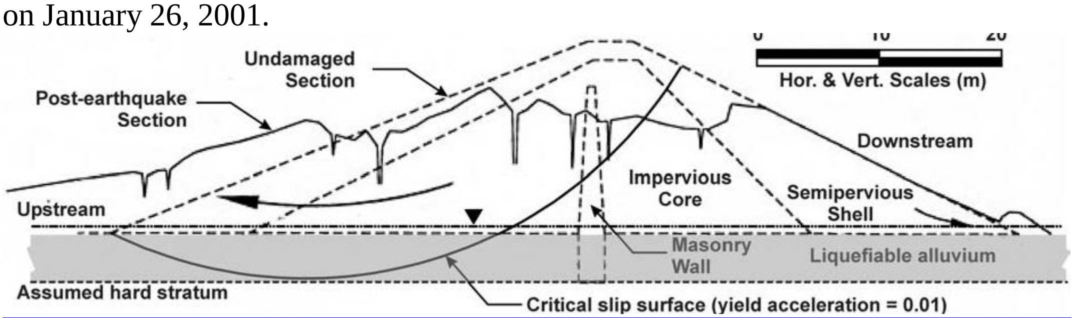
from http://en.wikipedia.org/wiki/File:PressurizedWaterReactor.gif

- Nuclear and thermal power plants. The use of water for cooling nuclear and thermal power plants is critical to meet the energetic needs of the next decades. The event in Fukushima, Japan last year should be a reminder of the constant threat and damage that can result from a nuclear meltdown. The design of water adequate cooling facilities is critical to the safe operation of nuclear and thermal power plants. These plants need to be designed by the best engineers in the country and CWPRS needs new research officers to meet the growing demand.

- Tsunami research – The Banda Aceh tsunami of December 26, 2004 has devastated the East coast of India. There is currently no physical modeling capability for tsunami research in India. There is an urgent need to build a tsunami research facility and CWPRS would be the best place for conducting coastal engineering research on tsunamis.

- Increasing energy demand – the hydropower demand increased from 12.7 to 18.5 Million tons of oil equivalent (MTOE) from 2006-2011 and the demand for nuclear power increased from 6.04 to 14.16 MTOE during the same time period. This corresponds to more than a 50% increase in hydropower and more than doubled nuclear power demand in the past 5 years. This will require new infrastructure for the power house, penstock, spillways, energy dissipation, etc.

- Liquefaction of dams - earthquakes have damaged some hydraulic structures, namely the Bhuj earthquake in Gujarat that caused liquefaction of the Chang Dam on January 26, 2001.



- Aging hydraulic infrastructure – In India, almost 1000 dams (out of 4291 in 1994) were built before 1971 and are more than 40 years old. Most dams need to be retrofitted to meet the present day demands. New masonry, cracked concrete, damage and tear from temperature changes, large floods and earthquakes have resulted in an increasing need to upgrade and retrofit hydraulic structures. Research in the new materials, non-intrusive geophysical techniques, the survey of seepage, liquefaction potential and new concrete and epoxy materials at CWPRS can rejuvenate aging hydraulic infrastructure.

- Flood damage – unprecedented floods have caused tremendous damage in recent decades. The example of the July 26, 2005 urban flash flood in Mumbai where 944 mm of rain fell in 24 hours.

- Climate change – the changes in climate pose immediate problems with extremely intense rainfall precipitation, water supply shortages during delayed monsoons, a gradual rise in sea levels (up to 5 mm / yr.) in coastal areas, etc.

- Environmental issues – There is an increase demand for the development of river restoration projects, advection and diffusion of urban effluents and chemicals in rivers from chemical plants, development in stream restoration, riparian zones, aquatic habitat, stream ecology, minimum in-stream flow needs, plankton and algae growth due to excessive nitrates and phosphates, fertilizers and pesticides in surface water, sand and gravel mining impact on bridges, heavy metals and actinides in mining areas, irrigation canal intakes, pumping plants, salinity intrusion problems in coastal areas, mangrove and wetland reconstruction, waterfront property development, socio-economic studies and eco-tourism, etc.

5.1.2 - Gaps with world-class facilities

Several gaps between the current facilities and operations have been identified.
The following list identifies some of the main areas that would need improvement:

- Power outages - Periodic power outages are frequent at CWPRS which may last from a few minutes to a half hour. These disrupt all measuring devices and delay experimental research. Such power outages are not acceptable in a world-class institution. It is essential to maintain continuous power supply at CWPRS.

- Renovation of buildings and large laboratories - There is an urgent need to upgrade the buildings and large laboratories as discussed in Task C1.

- General upgrade in laboratory equipment – The point has been made and more details are provided under Task C.

- Computer modeling – it is imperative to develop new technology based on numerical modeling. These numerical models will complement the large physical modeling operations at CWPRS. As discussed under Task A in the benchmarking analysis, CWPRS should still emphasize experimental research through laboratory experiments. Increasing the development of 2-D and 3D modeling techniques will definitely increase the status of CWPRS in relation to its peers. In the coming five-year plan, it is viewed that computational modeling should gradually increase to ~ 20% of the physical modeling activities.

- Environmental aspects – all benchmarked institutions are heavily into environmental modeling and applications. As discussed under Task A, there is no doubt that CWPRS should gradually engage to gradually expand the water quality modeling operations along the lines discussed above on emerging opportunities – environmental issues.

- Upgrading facilities and equipment - CWPRS used to benefit from significant resources from UNDP for upgrading the equipment, facilities and for training. As discussed under Task C, these funds have not been available since 1998 and about fifteen years later, there is now an urgent need for a massive investment in upgrading equipment, and facilities.

- Decline in sanctioned positions – CWPRS used to have 1857 sanctioned position in 2001. Today, this number has declined to 1172 which represents a 36% decrease in research effort at CWPRS. There is an urgent need to increase the number of sanctioned positions in order to meet the challenges and opportunities of the new millennium.

5.2 - Development Plan for CWPRS

As a result of my two field visits at CWPRS for this benchmarking analysis, I would like to offer the following plan to be developed for the next five years.

5.2.1 - New Research Officer Positions and Training

Several new research officers are required. A least 100 (possibly 200) new research officers should be added in the next five years. An appropriate number of support staff should also be added to support the new developed programs. Recruitment from top Universities in India and targeted recruitment of students who completed M.S. and Ph.D. degrees in the US and in Europe should be invited to give seminars at CWPRS. A breakdown in minimum number of requested positions follows:

- Tsunami research (5 RO positions)
- Coastal Environment, mangroves, tidal wetlands, and fisheries (5 RO positions)
- Coastal modeling in 2-D and 3-D (5 RO positions)
- River restoration and stream rehabilitation (5 RO positions)
- Point source river pollution and decontamination, advection-dispersion (5 RO positions)
- Non-point source pollution, irrigation and drainage, water quality and quality in agricultural areas (5 RO positions)
- Distributed flash flood modeling during extreme events (5 RO positions)
- River modeling with 2-D and 3-D models (5 RO positions)
- In-situ measurements for rivers, reservoirs and coastal areas (5 RO positions)
- Reservoir silting, turbidity, and sediment sluicing and flushing (5 RO positions)
- Earthquake impact on hydraulic structures (5 RO positions)
- Environmentally-friendly hydromachinery and hydraulic structures, fish ladders (5 RO positions)
- Cavitation, surge tanks, penstocks and waterhammer research (5 RO positions)
- Fluid- induced vibrations (5 RO positions)
- Urban runoff modeling, detention storage, channel incision control (5 RO positions)
- Turbulence measurements and modeling, PIV, CFD (5 RO positions)
- Energy dissipation, stepped spillways, baffle blocks (5 RO positions)
- Hydrometeorology of extreme events, satellite data transmission, delayed monsoons, sea level rise (5 RO positions)
- Thermal hydraulic engineering, cooling of nuclear and thermal power plants (5 RO positions)
- Retrofitting of aging hydraulic infrastructure, abrasion-resistant materials, epoxy concrete, new materials (5 RO positions)
- High-power computing, SCADA, servers, data acquisition, parallel processing, data storage, etc. (5 RO positions)
- Nuclear plant hydraulics cooling, dam-break modeling, manifolds, diffusers, evaporation tanks (5 RO positions)

5.2.2 - New Building #1 - Center for Eco-Hydraulic Research (CEHR)

A new building should be constructed (~ 18 cr) for the establishment of a new Eco-Hydraulic Research Center. The building should house approximately 80 new Research Officers. This building should be located near the large laboratories to stimulate exchange between physical modelers and numerical modelers. For instance, it could be physically located between the river and coastal engineering laboratories. The main components of this new building would be in the following areas:

- Advanced Computational Center (ACC) – The 2-D and 3-D modeling capabilities for rivers, reservoirs and coastal areas could be merged in a nice center within this new building. For instance, facilities with a main server, high performance computers and a host of numerical models could be available in this center. Among others, the system could host a number of codes including:
    - codes for CFD modeling in FLUENT, ANSYS, FLOW-3D
    - turbulent mixing CORMIX
    - river modeling HEC-RAS, RMA-2, DAMBRK, Mike
    - distributed modeling, GIS, ARC-GIS, ERDAS, TREX
    - decision support systems, MODSIM
    - coastal models, SUNTANS, TELEMAC, OUTRAY
    - navigation NAVIGA and MORMOT
    - geo-hydraulic models GEOSLOPE, FLAC3-D, Distinct EM

- Data Acquisition and Processing Center (DAPC) – A center for the data acquisition storage retrieval and processing of laboratory measurements. This center should have the capabilities to retrieve and store multi-channel and multi-dimensional data received from all physical laboratories at the station. The center would provide software for data acquisition, storage, processing and displaying. For instance, this could provide centralized operations for wireless data acquisition from the coastal laboratories, SCADA, ADCP and PIV, Geophysics. It may also include connection to satellites and provide 3D and 4D visual capabilities, graphics, time to frequency domain transformations, etc. These capabilities could also be spread-out throughout all laboratories while keeping central services for data display.

- Surface Water Quality Laboratory (SWQL) - current water quality modeling group to include large laboratory space devoted to the laboratory analysis of water quality in rivers, reservoirs and coastal areas. There could be an expansion of the activities on measuring water quality parameters like temperature, pH, BOD, fluorometry, organics, nitrates and phosphates and their impact on eutrophication and algae growth and control. The analysis should include the analysis of chemicals and industrial waste in surface waters, inorganics like PCB's and other similar contaminants. There could be new operations in relation to mining industries, as well as concentrations of heavy metals in adsorbed, dissolved and particulate phase, volatilization and photolysis, actinides, etc. The current investigations on macrophytes and plankton should be expanded to include chemicals, steroids, pharmaceuticals and bacterial growth in surface waters.

- River and coastal restoration research - New research areas relative to river restoration, stream rehabilitation, sediment contamination and management of spoiled dredged materials, aquatic habitat, stream ecology, riparian habitat, minimum in-stream flow needs, fish and wildlife studies, reconstructed wetlands and coastal mangroves and tidal wetlands. Environmental Impact studies could be conducted with the greater capabilities of physical and numerical modeling. There could also be economical impact studies, riverfront property development, canal boating or recreation, fishing, bike path and water parks in the vicinity of rivers, hydro-tourism, etc.

5.2.3 - New Building #2 - Welcome Center and Administrative Services (WCAS)

A new building should be constructed (~7 cr) near the main entrance of the Research Station. This building would serve the following functions:

- Welcome Center with a few physical displays, flat screens and videos
- The Director's Office and relevant office space for support staff
- A contracting office for the preparation of research contracts with CWPRS clients
- A couple meeting rooms for the clients and visitors in small (8-10) and larger groups (20-25)
- A Public Relations' Office with publications and printing capabilities for reports and posters, data archival, institutional statistics and annual reports, main server and firewall for the CWPRS network services and web page.
- Satellite data access with data transmission and retrieval –this could also be located at the CEHR
- Video- and tele-conferencing capabilities
- Training Center for short courses. The room should accommodate 30-40 people with high tech computers smart boards and could be combined with the video-conferencing capabilities.
- A Power control center with a power generator and non-interruptible power supply to secure continuous power for computational and physical modeling experiments. This generator may be located somewhere else if too noisy.
- A cafeteria for the clients, staff and visitors. The cafeteria should be a central point for lunches and exchanges of ideas among all researchers at the station.
- The auditorium is readily built and in the vicinity of this proposed new building.

5.2.4 - Renovations of Research Buildings and Equipment

The overall general renovations and equipment needs have been discussed under Task C. The renovated buildings (~ 10 cr) should benefit from the following items:

- Control rooms – renovate the control rooms in most large laboratories with modern computer equipment and appropriate data acquisition systems and data processing equipment. Wireless connections to measurement probes and devices should be provided whenever possible.

- Office space – renovation of office space with replacement of colony-era antiques like desks, tables, chairs, book cases and replace with new desktops and laptops with flat screens, decent chairs, lighting, dry-erase boards, and discard old CRT monitors, etc.

- Adequate air circulation, HVAC, fans and air conditioning in some areas would be desirable (the temperature in several offices and water quality laboratories were excessively hot during the first visit in June). Pune, normally benefits for rather nice weather and AC should not be necessary in the large-scale hydraulic and coastal laboratories. The control centers and RO offices may have fans or AC available. These control centers should be equipped with the latest equipment.

- The main building infrastructure should be checked, for structural damage, cracked masonry should be resurfaced (it is difficult to portray to clients that you are experts in retrofitting aging structures when the masonry of your own buildings is falling apart). Some signs and boards in front of some buildings and some laboratory flumes are at least half a century old (these do not give an impression of world-class infrastructure). Ancient windows need to be replaced in most buildings and laboratories, entrances should be inviting, office doors and hallways should be well lit and repainted, and there should be some meeting rooms in all buildings with dry-erase white boards for discussion. Parking lots should be paved with covered areas for scooters. There should be concrete, dry and covered walkways between buildings (currently there are muddy flats between several buildings, particularly during the wet monsoon).

- Electrical and plumbing systems should be redone – some of it may be dating from colonial times and may be somewhat dangerous. It was noticeable that several toilets were leaking in remote laboratory buildings were leaking during the visit (note that it is very difficult to claim to be world-class experts in closed conduits and cavitation when the visitors see and hear leaky toilets on the premises.)

- Aging pumps, generators and laboratory equipment should be upgraded as discussed in details under Task B.

5.2.5 - Autonomous Status

The possibility of changing CWPRS to receive autonomous status from the Ministry of Water Resources has been given serious consideration. Some of the current restrictions on international travel and the opportunities for advancement and promotion for productive staff members have been discussed under Task A.

On Thursday afternoon of the second visit (July 26), Drs. Gupta, Bhosekar and myself visited two autonomous institutes in Pune (the Indian Institute of Tropical Meteorology IITM of the Indian Meteorological Department, and the National Chemical Laboratory NCL). The notes from the visit in Appendix B showed that both institutes are doing extremely well under the autonomous status. Both Institutes have been autonomous for at least four decades. Dr. Goswamy at IITM clearly described their ability to recruit qualified personnel to work at IITM. He also explained the very competitive process of recruiting 32 new graduate students each year from a starting pool of 3000+ students. A new building is currently under construction and a similar building with high-tech computation facilities has been completed a couple years ago. IITM would not return to non-autonomous status.

With regard to NCL, the Director was traveling on July 26, but Dr. Ingle described the hiring process for top scientists at NCL. It starts with a targeted search and NCL has developed the capabilities to offer salaries and conditions comparable to European and American standards. He also explained a process by which the profits generated on projects can be redistributed to the principal investigators and also partly to all laboratory members. These funds are reinvested for additional equipment, travel and other needs.

Both institutes reflected a very high degree of competence and productivity. In both cases, the Director gained tremendously in freedom to hire new employees and to act as a executive officers for their respective Laboratory. This process seems a lot more effective than seeking permission from higher authorities in the Ministry of Water Resources. Both also indicated that the conditions for the employees are also keeping all the rights and privileges of the employees of the GoI.

In view of those visits, it became clear that CWPRS would greatly benefit from the autonomous status. The possibility has been discussed with the Board of Directors at CWPRS on Friday afternoon. The Joint Directors indicated overall support for the status change. Perhaps only two notes of caution have been expressed on Friday 7/27:

- Some CWPRS employees are concerned that there would be a change in the status of their employment and a loss of their rights and privileges. From the discussion with Dr. Gupta, it is clear that this would not be the case and all employees would retain all privileges of their current employment.

- There was a concern about the continuity in the transition process from the current state to autonomous status which may take 2-3 years to be fully approved. It was mentioned that Director Gupta's retirement is scheduled for September 2013 and none of the Joint Directors would be eligible for the Director position before 2015. It is most important to preserve continuity in the transformation process to autonomous status. This could be achieved either by extending Dr. Gupta's Director appointment until 2015, or by allowing one of the current Joint Directors (M.N. Singh, Bhave, V. Bhosekar, M.D. Kudale, S. Govindan, Ramteke or P.K. Goel) to assume the Director position upon the retirement of Dr. Gupta. In all events it is most important not to allow an external candidate to assume the CWPRS Director position during the transition period to autonomous status.

5.2.6 - Other Opportunities

One of the main opportunities coming up during this five-year period is that CWPRS will reach the centennial mark in 2016. It would be a great opportunity to show off with an International Conference to be held at CWPRS during 2016. National and International experts could be invited for the occasion. If all the building renovations and construction are complete, this would make a tremendous impression of the capabilities to recruit top candidates to fill new research positions at CWPRS.

The issue of a possible name change has also been discussed with the Joint Directors on Friday 7/27. There is a general consensus that a change to the National Hydraulic Research Institute – Pune or (NHRI-Pune) could be favorably retained as a new name for CWPRS. It is interesting that when discussing with clients and visitors during the luncheons on Thursday and Friday, the name CWPRS attracted a lot of attention and some visitors traveled all the way from Himachal Pradesh for meetings in Pune. The City of Pune is not easily accessible although there are several (4-5) flights to Delhi on a daily basis. International visitors are usually better off taking a 3-4 hour taxi ride between Mumbai International Airport and Pune. CWPRS is also somewhat remotely located form the main hotel areas located in the downtown area. It can easily take 1 hour to commute from the hotel to CWPRS. Some renovations of the VIP housing facilities are currently under progress. These facilities are within a few minutes of driving distance off the main Research Station.

My last thought on other opportunities to upgrade is based on the competence of CWPRS in several areas for which short courses could be developed. The following list of short courses could be developed for either training at CWPRS or at universities like U. Pune, the network of IIT universities with expertise in water like IIT Mumbai, IIT Roorkee, IIT Chennai, IIT Kharagpur and IIT Kanpur. When the buildings are fully constructed, it would then become interesting to offer short courses in the following areas:

- River engineering
- Sediment flushing and sluicing
- Coastal engineering breakwaters
- Navigation programs NAVIGA and MORMOT
- Energy dissipators
- Earthquake impact on hydraulic structures
- Retrofitting of aging infrastructure
- Masonry resurfacing and abrasion resistant materials
- Vibrations of hydraulic gates and structures
- Cavitation and hydromachinery testing

5.2.7 - Five Year Schedule

A five year plan may look something like:

Year 1 - 2012

- Filing for Autonomous Status
- Renovations of Existing Research Buildings
- Purchase of Laboratory Equipment
- Planning the construction of the two new buildings

Year 2 - 2013

- Renovations of Existing Research Buildings
- Acquisition of Laboratory Equipment (hardware and software)
- Starting the new building Construction
- Long-term and short-term training

Year 3 - 2014

- Renovations of Large Facilities
- Completing the new building construction
- Long-term and short-term training
- Planning HPC and software purchases
- Purchase of equipment for the new buildings

Year 4 - 2015

- Renovations of Large Facilities
- Long-term training
- Software purchases
- Hiring new RO

Year 5 - 2016

- Renovations of Large Facilities
- International Conference for the CWPRS Centennial
- New training courses offered at CWPRS
- Hiring new RO

5.2.8 - Budget

Overall the total budget required to bring CWPRS to the world-class level is the following. The plan budget below is in addition to the current level of expenditures in the non-plan budget

100 new RO + support staff	--	(~10 cr to base budget) - details S. 5.2.1.
New building #1 CEHR	18 cr	- details in Section 5.2.2
New building #2 WCAS	7 cr	- details in Section 5.2.3
Existing building renovations	10 cr	- details in Sections 5.2.4 + 3.1
Large Laboratory Facilities (tsunami, eco-hydraulic, thermal, Vibration)	25 cr	- details in Section 3.2
New equipment, hardware, software	16 cr	- details in Section 3.3 + Appendix C
Training	14 cr	- details in Section 4.3 + Appendix D
Total	**90 cr**	**(or ~ $ 18,000,000 USD)**

5.2.9 - Closing Statement

This development plan describes what, in my opinion, would bring CWPRS to the world-class level. The main conclusions of my report can be found in the executive summary at the beginning of the report.

In this report, I have attempted to express my views in the most constructive perspective. I shared a lot of ideas and perhaps only a few of them are valid for the future at CWPRS. If only one recommendation is implemented, the entire effort will prove to be worthwhile. None of my comments is intended to be critical of the current activities or management of CWPRS, Dr. I.D. Gupta and his team are doing an excellent job. I sincerely hope this report will serve to improve the facilities and lead CWPRS to the top Institute of its kind at the International level.

I appreciate the opportunity to work for the World Bank and specifically thank Dr. Anju Gaur for her very prompt and useful assistance throughout this benchmarking review process.

I also thank and congratulate Director Dr. I.D. Gupta for all he has achieved with his management team at CWPRS. His direct participation and involvement in most meetings, discussion and laboratory visits has been a source of inspiration. Director Gupta takes a very pro-active role in the improvement and upgradation of the facilities at CWPRS. My two week visits have been most productive because of the relentless effort of his management team and I particularly thank all the Joint Directors for their great effort in preparing summary presentations and very detailed development plans for their own discipline. The frank and open discussion have been greatly appreciated as well as the photos and videos that helped me remember the names of all those who made great technical presentations and guided memorable laboratory visits. To all, I am grateful for the opportunity to visit CWPRS and for the lively and productive meetings.

Pierre Julien, Ph.D., P.Eng.
7/31/2012 revised 10/18/2012

APPENDIX - A - Brief Report on the 1st Visit

Report on the 1st Visit of Dr. Julien at CWPRS June 11-15, 2012

Arrival in Mumbai on Sunday June 10, 2012 at 1:30 am
Benchmarking Review of CWPRS by Dr. Julien- June 11-15
Return from Mumbai: Saturday June 16 at 2:50 am

The objectives of this visit were:

- Carry out the objectives a) and b) specified in the TOR.
- Perform a systematic review of the research infrastructure of CWPRS to identify gap areas for making it a world class institute.
- Conducting performance benchmarking regarding the quality of service currently delivered by CWPRS.
- Meet the people working at CWPRS and foster synergy and enthusiasm.

My keyword for this visit: Listen

Following a discussion and review of the benchmarking objectives with the institutional leadership at CWPRS, my systematic review of CWPRS covered each of the seven disciplines identified in the TOR. I did spend approximately ½ day reviewing each discipline. My review covered the quantitative and qualitative aspects of the current operations.

Each discipline kindly fulfilled and exceeded all my expectations. At my specific request, each discipline provided detailed information on their current research activities. More specifically, the procedure has been the following:

- Summary Presentation (SP) ~ 1 hour

Each discipline leader presented a 50 min overall summary of the current activities in the given discipline. In most cases the leaders focused on a ppt presentation that highlighted the successes and accomplishments (~80%), a list of publications and reports, project types, experiments, design and construction, development of new techniques patents, awards and prizes, etc. Part (~20%) of the presentations has been dealing with an identification of limiting factors hindering growth and development in the particular discipline.

- Technical Presentation (TP) ~ 1 hour

Designated member(s) of each discipline did present a ~50 min technical presentation. The TP were typical of technical presentations at specialty conferences or at public hearings. Most presentations included a wealth of equations, formulas, integrals, new lab. and field measurement techniques, videos, and illustrate new design concepts and field application for engineering design, etc.

During both presentations, I asked numerous questions for clarification and also to gather as much information as possible on the breadth and depth of activities at CWPRS. For each discipline, the SP did give me information about the extent of the activities from a "management" viewpoint. The TP also provided me with information on the quality of the technology being used and developed at CWPRS from a "researcher" viewpoint. In some disciplines, the same person presented the material, but in many cases, the answers to my questions allowed several attendees to participate in the discussion. I noted that both Drs Gupta and Bhosekar attended just about all presentations.

CWPRS kindly provided summary information from all disciplines including both the SP and TP ppt files and additional material on a CD/DVD at the end of the week. This technical material along with all the photos taken during the week both in the labs and in the meeting rooms were extremely appreciated and informative for future reference. This information will be used in strict confidentiality.

The half-day review of each discipline did follow the recommended format:
(1) Brief meeting and introduction of the leaders and team members (~30 min)
(2) Summary Presentation by the discipline leader(s) + discussion (~90 min)
(3) Technical Presentation by the team member(s) of the discipline + Q&A (~60 min)
(4) Review of the facilities, lab. equipment, computer labs and software, etc. (~60 min)

Monday June 11th – morning

- Introduction with Director Dr. I.D. Gupta - Review of the TOR and of the benchmarking objectives and mandate of the Institute (re. TOR Task A)
- Presentation by the leadership team on the overarching operations of CWPRS, mission and vision statements, overview of budget and operations, infrastructure and management, accomplishments and challenges, etc. (1h)
- Introduction of myself – brief review of my credentials

Monday June 11th – afternoon
Review of *1) River Engineering*

Tuesday June 12th - morning
Review of *2) River and Reservoir System Modelling*

Tuesday June 12th - afternoon
Review of *3) Reservoir and Appurtenant Structures*

Wednesday June 13th - morning
Review of *4) Coastal and Offshore Engineering*

Wednesday June 13th – afternoon
I used this afternoon to sort, integrate and summarize all the information gathered at this point. There was an informal discussion with Drs Gupta and Bhosekar.

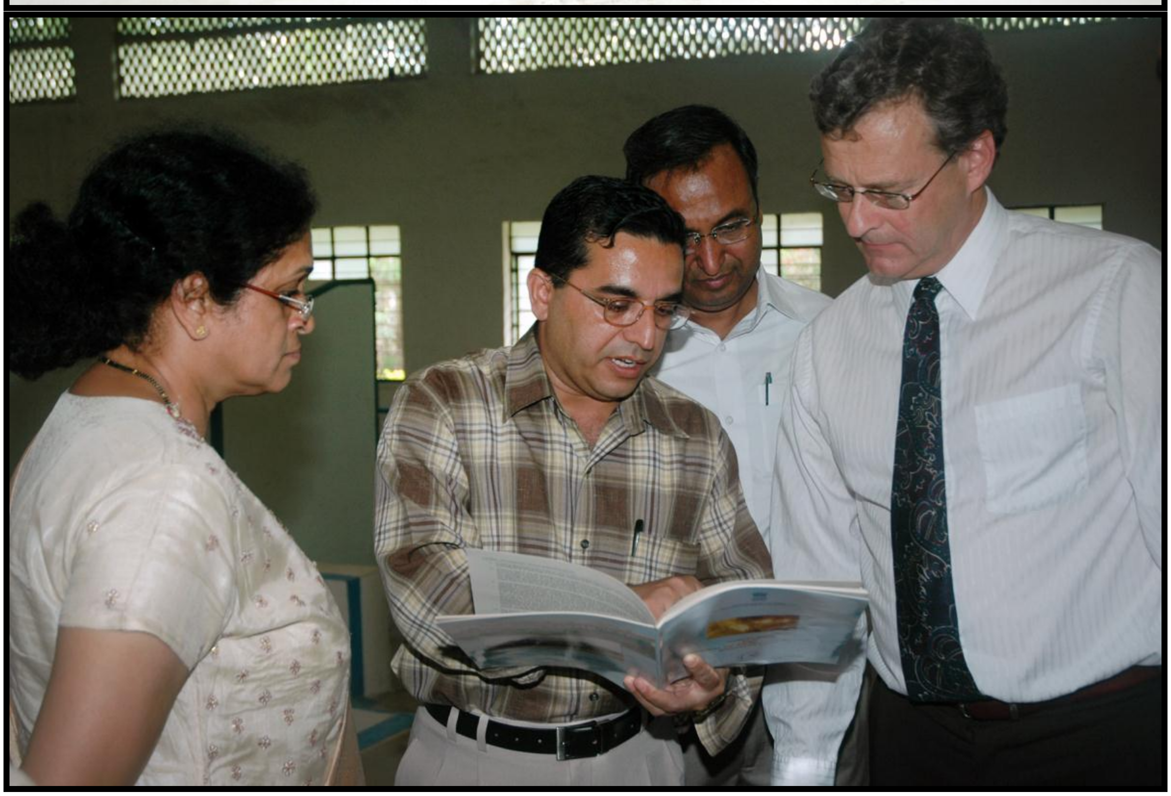
Thursday June 14th – morning
Review of *5) Foundation and Structures*

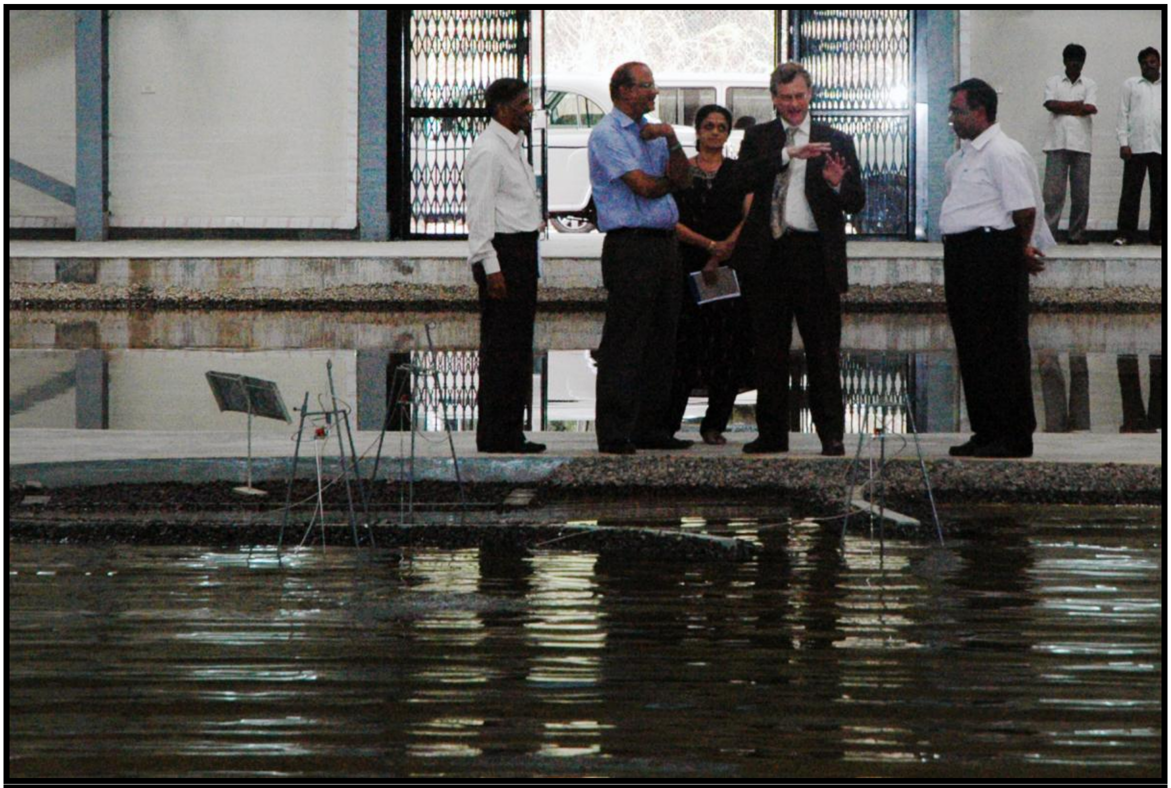
Thursday June 14th – afternoon
Review of *6) Applied Earth Sciences*

Friday June 15th – morning
Review of *7) Instrumentation, Calibration and Testing Services*

Friday June 15th – afternoon
The meeting with the leadership team allowed me some time to provide some feedback.
I essentially emphasized three things in my remarks:
1) I was highly impressed by all the presentations and the review of the facilities.
2) I emphasized the importance of the work that CWPRS is conducting. The example of the design applications of their work to nuclear power plants demonstrates the importance of their mission. CWPRS should continue to give the upmost priorities to the quality of their research for the secure development of water resources for the civilian populations.
3) I presented a plan for my second visit with emphasis on equipment/facilities and training needs. There was a brief Q&A session, followed up with discussion and dinner with Dr. Gupta and the management team.

Selected photos from the first visit





STRUCTURAL MODELLING & ANALYSIS(SMA)
FIELD STUDIES
STRAIN/DEFLECTION MEASUREMENT
Study of Drawings and inspection of Prototype / In-situ Structure
Site arrangements for Pressure Pumps, Rigid Platforms and Supports.
Unloading of structure and Stain Gauge installation at critical locations and recording of initial readings
Stage wise application of Pressure/Load and recording of data using Automatic Data Logger
Analysis and Safety Assessment based on design parameters.

APPENDIX - B - Brief Report on the 2nd Visit

Report on the 2nd Visit of Dr. Julien at CWPRS July 23-27, 2012

Draft 7-28-2012, revised on 9-13-2012

Final Schedule:
Arrival in Mumbai on Saturday July 21, 2012 at 1:30 am
Benchmarking Review of CWPRS by Dr. Julien- July 23-27
Return from Mumbai on Sunday July 29 at 2:50 am

Objective(s) of this visit:

- Carry out the objectives c) d) and e) specified in the TOR.
- Conducting performance benchmarking of CWPRS regarding possible new research areas in an effort towards world-class status.
- Perform a systematic review of the research infrastructure of CWPRS to identify opportunities for training and needs in laboratory equipments as well as computer hardware and software.

My keyword for this visit: <u>Plan</u>

This second visit did follow up on the activities started during my first visit. I did discuss the benchmarking objectives with the institutional leadership at CWPRS.
The second visit did focus on the objectives c), d) and e) of the TOR.
More specifically, I met with the members of each of the seven disciplines to: c) identify development of infrastructure facility by way of acquiring latest equipments and software for upgradation of the existing facilities; d) plan for strengthening the existing areas of research and suggest new areas of expansion in the sphere of activities at CWPRS; and e) plan for development capacity of researchers by way of identifying areas and training institutions abroad in the thrust areas of research.

Each of the seven disciplines identified in the TOR has been covered in a fashion similar to the first visit. I did spend approximately ½ day with each discipline.

Each of the seven disciplines has been requested and did provide the following detailed information:

1. Development Plan (1-2 pages) - A text description of the development plan for each discipline. This plan delineates the possible new areas of expansion within the mandate of CWPRS. These plans describe what actions should be taken to raise the current level of activities to a "world-class" level. These could specifically describe what changes in operations should be suggested, including training of current staff, recruitment of new research members, laboratory/field equipment needs as well as computer hardware and software needs. A detailed justification of expensive equipment/hardware/software/training items should be discussed in this development plan.

2. Equipment/computer/training List - A prioritized list of laboratory and field equipment, computer hardware and software, and training has been established for each discipline. It is only during the second visit that I expected each group to provide two separate lists for: (a) equipment including software and hardware for both computing as well as laboratory/field research; and (b) training. This should be viewed as a wish list, which serves as a basis for developing priorities. I have asked each joint director to prioritize their wish list such that the most pressing needs can be found at the top of the list. I have reviewed and discussed all lists with each discipline. In some cases, a laboratory visit was included to emphasize and illustrate the urgency of the request based on the level of deterioration of the aging equipment. I must say that I was very dismayed by the fact that some of the very basic equipment has been purchased as far back as the 1980's. They usually have been well maintained but not replaced or upgraded since. I am left with the very definite impression that most of the laboratory equipment (with few exceptions) dates one or several decades and there is an urgent need to upgrade most laboratory facilities and equipment. I intend to provide a summary of what I could consider as a top priority in the main text of my Final Report and intend to leave the detailed plans in Appendix. The following format has been suggested and used for the most part in order to list the items in order of decreasing priority. For instance items that are viewed as necessary for progress should be listed on top, followed by items that are needed and closed with items that are desirable. Note that this is just an example to illustrate the format.

Item	Type*	TD	Vendor	Cost
Well-logging Unit	L	IH	M.S. Turner Design Co.	4,500 Rs
HEC-RAS	S	RH	HEC, Davis CA	free
FLO-3D training	T	HMET	Colorado State University	3,500 USD
Diffractometer+	H	ADR	Dow chemicals, NJ	42,000 USD

* L for laboratory equipment, H for hardware, S for software and T for training.
+ this diffractometer is necessary for the physical modeling analysis on the New Delhi Bridge and for the Wazirabad Barrage Project.

During my second visit, during the week of July 23-27, I did spend ~1/2 day with each discipline in a format similar to the first visit. For each of the seven disciplines I did accomplish the following:

- Laboratory Visit (LV) ~ 1 hour

The leaders of each discipline have been given the opportunity to provide any supplemental information that could not be covered during the first visit. For instance, up to one hour has been made available for a visit of the laboratory facilities. The alternative of technical ppt presentations has also been used by several disciplines. I spent considerable time and attention to provide specific information on how to better present technical information. My review of the ppt presentations and the expression of my own perception of their work was been followed with very specific suggestions for improvement. This exercise has been rather well received by the Research Officers. I did ask quite a few questions and must congratulate all participants because they were all, without a single exception, very well prepared. This left me with a very positive impression on the technical competence and workmanship that I going on at CWPRS. The people I have interacted with worked very hard and demonstrated dedication to their field of research. My questions regarding some activities within each discipline were all very well answered.

- Development Presentation (DP) ~1 hour + discussion (30-60 min)

The joint directors of each discipline did present a ~60 min ppt presentation of the development plan that they proposed. The presentations included one or several lists of equipment/hardware/software and training for discussion. I often asked the leaders to integrate the lists prepared by each Technical Division within their discipline. I also reminded them to prioritize in decreasing order of importance. Finally I did request that each discipline present two lists: (a) equipment; and (2) training. For each discipline a folder containing a word file of their development plan, a ppt file of their development presentation and two lists for their equipment and training needs were compiled by Dr. V. Bhosekar and handed to me on Friday afternoon.

The half-day review of each discipline did follow the following format:
(i) Brief introduction of the discipline leader(s) and participating members (~10 min)
(ii) Laboratory Visit or Supplemental Information at the discretion of the discipline leader(s) + discussion (~ 60 min)
(iii) Development Plan presentation from each discipline (~60 min) + Q&A (~ 60 min)

At the time of the second visit, CWPRS (Dr. Gupta) kindly provided me with all the requested information on a CD/DVD with: (1) the development plans from item #1; and (2) an excel spreadsheet of the individual lists under item #2; and (3) the ppt files of the development presentations (DP). All files were included and can be properly read. I am extremely grateful to CWPRS for the efficiency with which they operated. I have also asked additional documents to Dr. Gupta on Thursday afternoon and the requested information has been provided to me very promptly and very accurately. The administrative operations at CWPRS run very effectively and in a very timely manner. I was pleasantly surprised that a photographer constantly monitored my venues throughout the week. Numerous photos and videos were taken during my visit, like the first visit I must say. We took the opportunity to have several group pictures. I have presented some selected photos from my first visit in the Interim Report. I simply report here that all the photos of the second visit have been compiled and attached to my request for the technical information described above. All this information has been compiled and been handed to me before departure on Friday late afternoon. Once again, I congratulate the management team at CWPRS for being so prompt and productive in delivering all requested information. It is a great pleasure for me to work in this kind of environment.

SCHEDULE of the 2nd visit

Note that the proposed schedule can be changed to respect customs and rituals (cultural and religious) that may be practiced in Pune at the time of the visit.
Actually, no changed to the proposed schedule have been made. Except perhaps that one laboratory visit first scheduled on Thursday morning was delayed til Friday morning because of the time constraint to visit the two autonomous Institutes on Thursday afternoon.

Monday July 23rd – morning

- Brief discussion with Director Dr. I.D. Gupta - Review of the objectives and proposed schedule for the second visit. (re. TOR Tasks B and C). Our meeting was brief and to the point regarding the planned program of activities for the week. I mentioned that I had kept Saturday July 28 free for any needed last minute meeting. However, I had planned the entire program to be completed by Friday afternoon and we were all satisfied with completing the entire program on time.
- Discussion with Ex-Directors and Additional Directors of CWPRS (1 hour). This meeting went very well with discussion with Mrs Bendre who has been director for a long period of time (~ 10 years) and with Dr. Tarapore who has been Director quite some time ago. He is still very bright and he is still very active with the Danish Hydraulic Institute.
- Seminar by Dr. Julien on his own research activities at Colorado State University 60 min presentation + ~30 min Q&A.) . I presented a one hour talk entitled "The Power of Collaborative Research" with examples from my own experience at the National and International Level. Drs Anju Gaur from the World Bank and the two ex-Directors Bendre and Tarapore attended the presentation. The Auditorium was full and additional chairs were brought in for additional participants. The presentation was followed by brief statements from Drs Gaur and Tarapore as well as Mrs Bendre. The forum was then opened up to the broad audience who asked several questions. All went well and my only concern was that I regretted not having brought my ties, inadvertently left home in Colorado before leaving.

Monday July 23rd – afternoon
Review of *1) River Engineering*
Interesting presentation from M.N. Singh with a nice and articulated plan for future research.

Tuesday July 24th - morning
Review of *2) River and Reservoir System Modelling*
Also a nice presentation from Mr. Bhave.

Tuesday July 24th - afternoon
Review of *3) Reservoir and Appurtenant Structures*
Dr. Bhosekar prepared a very detailed plan and spent considerable time finding detailed information on experts in the field for possible visits and invitations to CWPRS.

Wednesday July 25th - morning
Review of *4) Coastal and Offshore Engineering*
Mr. Kudale gives tremendously well-illustrated presentations.
His plan was well thought through and very important to the future of CWPRS.
Incidentally, I also had lunch with a group of visitors from the Asian Development Bank on Thursday luncheon. The visitors were very eloquently speaking about the expertise on CWPRS in the area of Coastal Engineering. CWPRS has acquired a tremendous reputation nationwide and also at the international level. This has been accomplished with very limited ability to travel outside India and without any marketing strategy to enhance visibility of the Research Station. I found this accomplishment of CWPRS to be very laudable.

Wednesday July 25h – afternoon
Review of *5) Foundation and Structures*
Mr. Govindan has been visibly bothered by flu and headache symptoms during that week. His colleagues presented the development plan. Mr. Govindan did not miss a single presentation or meeting, and this speaks to his commitment to CWPRS. The activities in this discipline are also very important to the mission of CWPRS.

Thursday July 26th – morning
Review of *6) Applied Earth Sciences*
Mr. Ramteke presented a very coherent development plan. The AES group also plays a very important role in the analysis of geophysical information and the impact on improving the design of hydraulic structures.

Thursday July 26th – afternoon
Visit of Autonomous Institutes in Pune.
India Institute for Tropical Meteorology(IITM), which is part of the India Meteorological Department (IMD)
We met with Dr. Goswamy who is Director of IITM for about one hour and discussed the pros and cons of the autonomous status which has been acquired at IITM since 1972. Dr. Goswamy unequivocally expressed the very positive impact of the autonomous status on the ability to hire and recruit top people. He described a process whereby 32 trainees are selected each year from a pool of some 3,000 applicants. He described the productivity of the Institute as being very high. A new building has been constructed 3 years ago with a tremendous high power data management center. A new building replicating the shape of the first building is currently under construction and should be completed next year. He described that the autonomous status is very positive in reducing the paperwork and being more efficient and productive in hiring new employees. In fact, he had to excuse himself at the end of our meeting to join a selection committee for a new hire.

National Chemical Laboratory (NCL)
Dr. Ingle spend truly valuable time with Drs Gupta, Bhosekar and myself in explaining the historical developments at NCL from basic research to applied research and nowadays towards more production. The director was in Europe during the visit and his schedule indicated that he frequently travels abroad. Dr. Ingle described the hiring

process by which NCL selectively determines who they would like to hire. They actively pursue selected top candidates and make them offers comparable to what would be possible for extremely successful scientists at other Institutes in Europe or the US. The salaries and conditions are very competitive and the productivity is extremely high. There are currently ~700 employees at NCL with 192 researchers and the number of refereed journal publications last year was about 396 refereed papers. NCL has a very elaborate system to return benefits from successful projects back to the employees and the resources can then be used by the employees to travel abroad and undertake collaboration at the international level. In summary, the operation seemed to run very smoothly and with the highest possible level of excellence and international visibility. Dr. Gupta indicated that NCL benefited from a special status from the Ministry of Science and Technology. It should be pointed out that things may be different under the Ministry of Water Resources.

These two visits were very instrumental and educative. It seems that the autonomous status at CWPRS would be very beneficial to: (1) reduce the administrative paperwork with the Ministry of Water Resources; (2) provide a more selective and direct involvement in the hiring of world-class new employees; (3) open up new possibilities with international contracts; (4) enable employees at CWPRS to participate in international conferences; and (5) provide flexibility and reduced paperwork for the CWPRS Director. It is interesting to note that there seems to be no difference with the advantages and privileges of the employees since the employment status through the GoI is the same with or without autonomous status. It is important to note that this should be important to mention to the CWPRS employees in that a change to autonomous status would not take any privilege away from what they already have. It seems that they could only gain new opportunities in changing to autonomous status. In summary, there seems to be only advantages to the autonomous status. However, there is no doubt about the increased productivity, flexibility and dynamism that the autonomous institutes currently have. It seems to be a successful model, which I discussed with the joint directors on Friday afternoon.

Friday July 27th – morning
Review of *7) Instrumentation, Calibration and Testing Services*
Mr. Goel made a forceful and interesting presentation on aging of the facilities that he manages and the need for immediate upgradation of critical facilities. He presented a very interesting plan, which was followed by four laboratory visits.

Friday July 27th – afternoon
A meeting with Dr. I.D. Gupta and his leadership team did provide some feedback.
I presented a few powerpoint slides on my interim report. This was followed by a critical discussion on the autonomous status. The change would be generally welcome by the current joint directors at CWPRS. The only signs of reservation were on preserving the rights and privileges of the current employees. It is clear from Dr. Gupta's response and my own observations that all current employees would retain all privileges and conditions acquired to date. There was also an indicated need to preserve continuity in leadership during the transition to autonomous status. The case in point is rather unique in that Dr.

Gupta is scheduled to retire next year while there would be a 2 year gap before any of the current joint directors would be eligible to apply for the Director position. It is crucial that during the transition phase to autonomous status, the Director position should be held by either Director I.D. Gupta, or one of the seven joint directors in (Singh, Bhave, Bhosekar, Kudale, Govindan, Ramteke, or Goel). It is extremely important that no external director should be interjected during the transition process to autonomous status.

Saturday July 28th – all day
This last day has been left available to review any item of the weekly program that could not be completed. The plan has been completed to the satisfaction of both Dr. I.D. Gupta and myself on Friday afternoon. Further discussion will be done via email. I mentioned the plan to submit my Draft Final Report before the end of August. The Draft Final Report will then be reviewed by Director Gupta and by the World Bank prior to submitting the Final Report.

I worked on this final draft report all day on Saturday and during the return flights on Sunday. This has been a challenging and physically demanding trip. All expectations for this trip have been successfully met and I should have all the information needed for my final report.

Pierre Julien
7/28/2012

Selected photos from the 2nd visit


Gravimetric and Volumetric Calibration Laboratory
AREA OF UPGRADATION
• Parallel/independent Operation of both test line
• Calibration under non-standard installation conditions
• Computational Fluid Dynamics (CFD) set up for pump intake model studies
• Experimental set up for cavitation in turbo machinery
• Renovation of large pump test circuit rig


Indian Rainfall Projection


PROPOSED BARRAGE


IDENTIFICATION OF NEW AREAS OF RESEARCH (CONTD.)
• Discharge computation using end depth method in steep slope channels
• Effect of variation in bed materials for river models
• Parametric study for river sedimentation
• Environmental Impact Assessment


SEA LEVEL RISE
Objectives:
Knowledge concerning mean sea level changes
Review established rate of sea level changes
Re - establish SLR for local areas
Project sea level rise for engineering use - 100 years
Examine potential effects on engineering works
Measures for preventing erosion & inundation
Assessing of New policies or technologies
CENTRAL WATER & POWER RESEARCH STATION


SPATIAL DATA – THEMATIC MAPS
Raster Maps:
DEM, Landuse, Slope, HSG Map, Thiessen Map, Sub-Watershed


PRESENT AREAS OF WORK - RECAP
Location & hydraulic design of power intake vis-a-vis
Protection Works
River
Location
of
Intake
SEA
Lake / Reservoir
Development Plan


DENSITY CALIBRATION PITS


FLUOROMETER


COASTAL DATA CENTRE


TP


अनुसंधान के माध्यम से सेवा
केन्द्रीय जल और विद्युत अनुसंधान शाला, पुणे


TREX: Two Dimensional Runoff
Erosion and Export
HYDROLOGY
FLOODPLAIN
CENTRAL WATER AND POWER RESEARCH STATION, PUNE
Service through Research


Danyawaadh!
pierre@engr.colostate.edu


Erosion and
Sedimentation

APPENDIX - C - <u>Detailed List of Equipment Needs at CWPRS</u>

Equipment Needs at CWPRS

This Appendix presents a detailed list of equipment needs for each discipline. Each discipline has been requested to prepare a detailed "wish" list for presentation and discussion during my second visit. A significant effort has been made by the leaders of each discipline and the needs are real. Each list has been prioritized with the highest priority item on top of the list. My own appraisal of the approximate sum that would be needed for each discipline is presented in the summary table below. The items in the following list may be reviewed in light of the budget available for each discipline.

<u>Summary</u>

River Engineering	2 cr
River and Reservoir Systems Modelling	2 cr
Reservoirs and Appurtenant Structures	2 cr
Coastal and Offshore Engineering	4 cr
Foundations and Structures	1.5 cr
Applied Earth Sciences	1.5 cr
Instrumentation, Calib. and Testing Services	3 cr
TOTAL	16 cr

River Engineering (2 cr)

I. LABORATORY EQUIPMENTS REQUIRED

S.NO.	Item	Make	Approx. Cost (Lakhs Rs)	Training Required
1	Acoustic Digital Currentmeter (ADC) / Accoustic Doppler Velocimeter (ADV)	SONTEK, USA/NORTEK, Norway	32	Yes
2	Flow Tracker	SONTEK, USA/NORTEK, Norway	20	Yes
3	Mini echo sounder	General Acoustics, Germany	10	Yes
4	2D bed profiler	HR Wallingford	45	Yes
5	Particle image velocitymeter	SONTEK, USA/NORTEK, Norway	62	Yes

II. SOFTWARE REQUIRED TO BE PROCURED

S.NO.	Item	Make	Approx. Cost (in Lakhs Rs)	Training Required
1	Autocad CIVIL 3D	Autodesk Asia Pvt. Ltd., Singapore	2.5	Yes
2	ARCGIS 10.1	ESRI	10	Yes
3	MATLAB	MATWORKS	5	Yes
4	ERDAS	Intergraph corporation, Madison, USA	5	Yes
5	MIKE 21 C/ DELFT 3D	DHI, Denmark/ DELFT	25	Yes
6	FLOW 3D	Flow Science Inc., Santa Fe., New Mexico	35	Yes
7	Fluidyn- FLOWCOAST	Fluidyn-India	15	Yes

River and Reservoir Systems Modelling (2 cr)

List of Equipment / Software / Training for R&RSM Group

Rank	Item	Type	TD	Vendor/ Institute	Indicative Cost in Lakhs Rs
L1	Water Quality Monitor with pH, cond, Temp, DO, nitrate and chlorophyll probes	L	WQAM	In Situ Inc, YSI, Horiba, Hach- Hydrolab	15
L2	Compound Microscope with colour digital camera	L	WQAM	Carl Zeiss / Olympus / Leica 40x-2500x	4
S1	MIKE 11 (With R-R, Sediment, Hydrodynamics, WQ Modules with basic and hands on training)	S	SWH/ HM/ WQAM	DHI (INDIA) NSIC Bhawan, III Floor, NSIC - STP Complex Okhla Industrial Estate New Delhi - 110020 Phone: +91-11-47034500 Fax: +91 11 4703 4501 dhi-india@dhigroup.com www.dhigroup.com	20
S2	MIKE FLOOD Flood zone Mapping	S	SWH/ HM	DHI (INDIA) New Delhi	25
S3	MIKE SHE Distributed Rainfall-Runoff modeling	S	HM	DHI (INDIA)	12
S3	MIKE Basin including WQ module	S	WQAM	DHI (INDIA)	6
T1	Distributed Hydrologic Modelling (3 months)	T	HM	1. Colorado State Univ 2. Utah State Univ.	26
T1	2-D Flow Modelling	T	SWH / HM	1. Colorado 2. DHI, Denmark 3. IIHEE, Delft	10
T1	Environmental and water quality modelling	T	WQAM	ASCE, USGS, DHI, USEPA	15
T2	Water Resources Planning and Management (3 weeks)	T	HM	IIHEE, Delft	3.5
T3	M.Tech (Water Resources)	T	SWH	The Chairman, PG Admissions office, IIT Roorkee, Roorkee-247 667, Uttarakhand	2

Reservoirs and Appurtenant Structures (2 cr)

Sr. No.	Item	Type	Technical Division	Vendors	*Cost in Lakhs Rs.*
1.	PIV /LDV/ADCP for turbulence measurement	L	SED, CSWCS, SM	Dantec, Measurement Science Enterprise Inc., USA-LDV LaVision UK Ltd., UK-PIV Sutron, USA and Sontek, USA-ADCP	120
2.	Air concentration measurement system	L	SED, CSWCS	Prof. Chanson, University of Queens land, Australia	10
3.	Acoustic Doppler currentmeter	L	SED, CSWCS, SM	A-OTT, Germany	8
4.	Propeller type current meter	L	SED, CSWCS, SM	A-OTT, Germany	5
5.	Digital pointer gauges	L	SED, CSWCS, SM	HR Wallingford, UK	1
6.	Sediment Bed Profiler	L	SED, SM	HR Wallingford, UK	5
7.	Digital water level recorders/follower	L	SED, CSWCS,SM	HR Wallingford, UK	1
8.	Ultrasonic/Magnetic flow meter	L	SED, CSWCS,SM	Geotech Environmental Equipement, Denver, Colorado	3
9.	Air flow anemometer	L	SED, CSWCS	Calright Instruments,2222 Verus Street,Suite C,San Diego, CA 92154	0.8
10.	Particle size analyser	L	SM	Sequoia, 2700, Richards road, suite 107, Bellevue, WA 98005, USA	30
11.	Accelerometers	L	CSWCS	Dytran Instruments Incorporated CA , USA	10
12.	Strain gauges	L	CSWCS	Micro-Measurements, PO Box 27777, Raleigh,NC 27611,USA	5
13.	Sediment injector	L	SM	HR Wallingford, UK	2
14.	Swirl meters for open channel flows	L	SED, CSWCS	AALBORG Orangeburg, New York USA	
15.	Transient analysis software	S	CSWCS	HYTRAN and HYPRESS	35
16.	Computational Fluid Dynamic software	S	SED, CSWCS, SM	FLOW-3D, FLUENT, STAR-CCM, FLUIDYN	30

Coastal and Offshore Engineering (4 cr)

Sr. No.	Item	Type	TD	Vendor	Cost
Software & Hardware :					
1	Optical Motion Tracking System	H	PH	Qualysis, Sweden / Singapore	Rs. 66 lakhs
2	Force & Deflection Transducers	H	PH	--	Rs. 25 lakhs
3	Tsunami Wave Generating Laboratory	H	CHS	--	Rs.15,00,00,000 (Approx.)
4	SHIPMA (Ship Navigation)	S	MMCE	MARIN, Netherlands	€ 35,000
5	OPTIMOOR (Ship Motion)	S	MMCE	TENSION Technology International, UK	$ 15,000
6	MIKE FLOOD (Coastal Urban Flooding)	S	MMCE	DHI	Rs. 25 Lakhs
7	LITPACK (upgraded version)	S	MMCE	DHI	Rs. 40Lakhs
8	HEC-RAS	S	MMCE	HEC, DAVIS CA	free
9	SMS (Wave modelling)	S	CHS	Aquaveo, Provo, Utah, USA	$ 22,500
10	Dredge – Sim	S	MMCE	University of German Armed Forces, Munich	--
11	SEDPLUME	S	MMCE	HR Wellingford, UK	7000 £

Foundations and Structures (1 .5 cr)

LIST OF SOFTWARE

Sr.No.	Item		Type	TD	Probable Vendor	Approx. Cost in Lakhs Rs.
1	"HYPERWORKS" FINITE ELEMENT SOFTWARE	1 Nos	S	SMA	M/S ALTAIR, USA (M/S ALTAIR, Pune,India)	35
2	GEOSLOPE (Proprietary Software)	1 Nos	S	GE(Soil)	Geo slope International	15
3	FLAC-3D (Proprietary Software)	1 Nos	S	GE(Soil)	ITASCA	12
4	Midas GTS (FEM Software)	1 Nos	S	GE(RM)	MIDAS, India	8
5	UDEC (2D Discrete Element Software)	1 Nos	S	GE(RM)	ITASCA, India	8
6	3DEC (3D Discrete Element Software)	1 Nos	S	GE(RM)	ITASCA, India	14
7	ANSYS FEM Software - Thermal Module	1 Nos	S	CT	M/s ANSYS Software Pvt. Ltd. 34/2 Rajiv Gandhi Infotech Park, MIDC Hinjewadi, Pune 411057	20

LIST OF EQUIPMENTS

Sr. No.	Item		Type	TD	Probable Vendor	Approx. Cost in Lakhs Rs.
1	Cyclic Triaxial Soil Test System	1 Unit	L	GE(soil)	1.GDS Instruments, UK 2.ELE international 3.HEICO Engg. Pvt. Ltd.	50
2	Automated Static Triaxial Shear Test (For measuring Shear strength parameters, c and Φ of soil)	2 Units	L	GE(soil)	HEICO Engg. Pvt. Ltd	14
3	Automated Direct Shear Test Apparatus (For measuring Shear strength parameters, c and Φ of sand / silty sand)	4 Units	L	GE(soil)	AIMIL	3

4	Fully automated Consolidation Test Setup(For determining Consolidation characteristics for computation of rate of settlement as well as Total settlement of foundation due to structure.)	2 Nos	L	GE(soil)	HEICO Engg. Pvt. Ltd	1
5	Fully automated Laboratory Permeability test apparatus (For determining Permeability characteristics of soil for seepage analysis)	3 Units	L	GE(soil)	HEICO Engg. Pvt. Ltd	1
6	Laboratory Vane Shear Apparatus (For determining Undrained Shear strength of marine clay)	1 Unit	L	GE(soil)	AIMIL	1
7	Electronic Balances (For taking weights of samples in soil testing)	1 Nos	L	GE(soil)	HEICO Engg. Pvt. Ltd	0.5
8	De-aired Water System (For usuage of de-aired water in Triaxial testing)	1 Unit	L	GE(soil)	AIMIL	1
9	Hydraulic operated Sample Extractor (For extracting 38mm dia samples for testing from 100mm dia open end sampler tubes.)	1 Nos	L	GE(soil)	HEICO Engg. Pvt. Ltd	0.3
10	Hydro fracture test equipment	1 Nos	E	GE(RM)	Polymetra GmbH, Froschbach 15 CH-8117, Fallanden, Switzerland	20
11	Bore Hole TV Camera	1 Nos	E	GE(RM)	M/S Robertson Geolgging Ltd. represented in India by K. I. Ltd. Kolkata	14
12	Servo - Hydraulic unit with system for flexural tests on Fibre Reinforced Concrete for determining its Toughness Index	1 Nos	E	CT	1.M/s CONTROLS S R L, Via Aosta, 6, 20063 Cernusco s/N.(MI), Italy 2. M/s International Trade Links Instrumentation Pvt. Ltd, Mumbai	45

Applied Earth Sciences (1.5 cr)

List of Software –Geophysics Division

Sl. no	Item	Type	TD	Probable Vendor	Cost in USD
1	Tomographic Inversion software for analysis compatible with Windows + Software for seismic refraction data processing	Soft-ware	GP	**1.** M/sSandmeier scientific software Zipser Strasse 1 76227 Karlsruhe, Germany **2.** M/sGeometrics, 2190 Fortune Drive San Jose, CA 95131 USA	USD 10,000

List of equipment- Geophysics Division

Sl. no	Item	Type	TD	Probable Vendor	Cost (in USD)
1	Seismic borehole shear wave system consisting of i) Impulse generator, Remote Control Unit, Down hole probe P- wave source and Down hole probe S- wave sources ii) Borehole geophones iii) Borehole inclinometer (This system is not available in the division)	F	GP	Geotomographie GmbH Am Tonnenberg 18 56567 Neuwied Tel.: +49 2631 778135 Fax.: +49 2631 778136 email: info@geotomographie.de Internet: http://www.geotomographie.de	USD 50,000 USD 20,000 USD 5000
2	Seismic borehole tomography system consisting of i) Hydrophone chain with moulded elements (One hydrophone chain is purchased in 2003 and presently it is not working and irreparable)	F	GP	1. Geotomographie GmbH Am Tonnenberg 18 56567 Neuwied 2. M/s OYO Corporation 2-6 Kudan-kita 4-chome, Chiyoda-Ku, Tokyo 102-0073, Japan	USD 25000
3	Signal enhancement seismograph with Geode/Snap on technology.	F	GP	1. Geometrics USA, 2190 Fortune Drive, San Jose, CA 95131 USA P: (408) 954-0522 F: (408) 954-0902 sales@mail.geometrics.com	USD 60,000
Sl. no	**Item**	**Type**	**TD**	**Probable Vendor**	**Cost**
4	Underwater Sub-bottom profiling system (Present "Chirp" system available has 20 m penetration in coarse calcareous sand. We need system with higher penetration up to 50 m.)	F	GP	1. Knudsen Engineering, Canada, Knudsen Engineering Ltd. 10 Industrial Road, Perth, Ontario CANADA K7H 3P2 Telephone: (613) 267-1165 Fax: (613) 267-7085 sales@knudsenengineering.com http://www.knudsenengineering.com	USD 60,000
5	Batteries and cables of specifications for Ground Penetrating Radar system (One set of batteries purchased along with equipment gives backup of 1 hr only. We need another two sets of batteries for continuous operation.)	F	GP	M/s ABEM, Skolgatan 11 930 70 Malå, Sweden 0953-345 50	USD 5000

List of Equipments - Isotope Hydrology Division

Sr. No.	Item	Type*	TD	Vendor	Cost(in Lakhs Rs)
1	Well logging Unit (with Borehole camera system)	F	IH	1) R G well Logging, 10801 Hammerly Blvd., Suite 202, Houston, TX 77043 USA 2) Mount Sopris, 17301 W Colfas, Suite 255 Golden, Dolorado 80401 USA 3) OYO Corporation Instruments Division, 2-19 Daitkudo 2- chome,URAWA, Saitama 336 Japan	50
2	Field Fluorometer	F	IH	1)Turner Design, 845 West Maude Avenue Sunnyvale CA 94085 2) ADC BioScientific Ltd, 1st floor Charles House, Furlong way, Great Amwell ,Herts, SG 129TA, UK	12
3	Well logging software (Well CAD & Viewlog)	S	IH	Advanced logic Technology Batiment A, route de Niederpallen L-8506 redange sur attert Luxembourg**	5
4	Lablోratory Fluorometer	L	IH	1)Turner Design, 845 West Maude Avenue Sunnyvale CA 94085 2)Chelsea Technologies Group Ltd, 55 Central Avenue, West Molesey, Survey KT8 2QZ UK 3) ADC BioScientific Ltd, 1st floor Charles House, Furlong way, Great Amwell ,Herts, SG 129TA, UK	8
5	Spares, accessories and caliper probes for existing R G well logging equipment.	F	IH	R G well Logging, 10801 Hammerly Blvd., Suite 202, Houston, TX 77043 USA	10
	Rhodamine kit for laboratory fluorometer	L		Turner Design, 845 West Maude Avenue Sunnyvale CA 94085	1
6	Liquid scintillation counter	L	IH	Vendor: HIDEX, Mustionkatu 2, FIN-20750 Turku, Finland info@hidex.com, firstname.lastname@hidex.com	15

*F→ Field Instrument, L→ Laboratory Equipment, S → Software
** Training for software will be provided by the vendor

List of Proposed Equipment for VT Div.

Sr. No.	Item	Type*	TD	Probable Vendor	Cost in Lakhs Rs.
1	24 Channel Signal Enhancement Seismograph with accessories*	Field & laboratory equipment	VT	1. ABEM Instrument AB, Sweden 2. Oyo Corporation, Japan 3. Geometrics,Inc, CA 95131, USA 4. Seismic Source Company, USA.	28
2	Structural Health Monitoring System along with software**	Field & laboratory equipment	VT	1. M/s Apna Instrumentation & Solutions, Pune 2. M/s National Instruments Systems (India) Pvt. Ltd., Bangalore	10

***: 24 channel equipment is not available in the division.** 12 Channel Seismograph purchased in 1986 has become obsolete, and unserviceable.

: **Equipment is not available in the division.

Justification

1. **24 Channel Signal Enhancement Seismograph:** Non-destructive technique is used for testing the quality and homogeneity of concrete/masonry structure. Presently 12 Channel Seismograph purchased in 1986 is used for such studies and has become obsolete, and unserviceable and hence need to be replaced by advanced and state of the art technology equipment, viz. 24 Channel Signal Enhancement Seismograph. The equipment is with advanced features like digital storage, windows operated and with software controlled analysis features and hence, it will take less time for sonic testing.

2. **Structural Health Monitoring System (SHM) along with software** is proposed to be used for structural health monitoring of civil engineering structures like dam, bridges, tunnels, critical structures etc. It is proposed to procure various types of sensors and amplifiers for SHM.

List of proposed Softwares for VT Div.

Sr. No.	Item	Type*	TD	Probable Vendor	Cost in Rs. in Lakhs
1	Shock Software for Electro Dynamic Shaker	Software	VT	M/s Spectra Dynamics Inc., USA (Proprietary Item)	2.5
2	Advanced Vibration Management Program	Software	VT	M/s Orica Mining Services, Australia (Proprietary Item)	2

Justification

1) **Shock Software for Electrodynamic Shaker:** This is a proprietary article of M/s Spectral Dynamics, USA, proposed to be used with existing Electrodynamic shaker purchased in 2011. After procurement of the software existing Electrodynamic shaker can be upgraded for simulating earthquake, operated for fixed sine frequencies and for generating half sine for short duration which are essential for Block Vibration Tests.

2) **Advanced Vibration Management Program** This is a proprietary article of M/s Orica Mining Services, Australia to evaluate vibration and air blast data by using the Monte Carlo simulation technique. The vibration impact of proposed blast designs can be modeled and assessed to ensure corrective actions to be taken in blasting patterns.

List of Equipments (ES DIVISION)

Sr. No.	Item	Type	TD	Probable Vendor	Cost in Rs. In Lakhs
1	Digital Microearthquake Recorder (Out of ten available equipment, four were installed at Ujh Project, Jammu & Kashmir and remaining six are not in good working condition. These instruments were procured on August -2004)	F/L	ES	1.Refraction Technology Inc.(REFTEK), USA 2. M/s GeoSIG Limited, Switzerland 3. M/s Kinemetrics Inc., USA 4. M/s Gurlap Systems, UK 5. M/s GeoTech Instruments, LLC, USA 6. M/s Nanometrics, Canada 7. PMD scientific Inc, USA 8. Eentec, USA	7,00,000 * 5 =35
2	Digital Strong Motion Accelerograph (Out of ten available equipment four were installed at Nagarjunasagar Project, Andhra Pradesh and one at Ujh Project, Jammu & Kashmir and remaining five are not in good working condition. These instruments were procured on March-2004)	F/L	ES	1.Refraction Technology Inc.(REFTEK), USA 2. M/s GeoSIG Limited, Switzerland 3. M/s Kinemetrics Inc., USA 4. M/s Gurlap Systems, UK 5. M/s GeoTech Instruments, LLC, USA 6. M/s Nanometrics, Canada 7. PMD scientific Inc, USA 8. eentec, USA	5,40,000 * 3 =16
3	Data retrieval Unit (Five Units, these units were part of the instruments only and were compatible to the instruments. These instruments were procured on March-2004)	F/L	ES	Supplier of the above equipments	60,000 * 3 =1.8
4	Global Positioning System (One Unit, this instrument was procured on March-2005)	F/L	ES	1. Garmin (Asia) Corporation, Taiwan 2. Magellan, USA 3. Bushnell Corporation, USA 4. Lowrance, USA	45,000 * 2 = 9

Justification

Presently available equipments have been extensively used for various projects, e.g. Bunakha Project, Bhutan, Somwarpet Project, Karnataka, Mullamuri Project, Karnataka etc. They are nearly 10 years old. They have served their useful life and now most of them are not in good working condition. GPS available has only 2MB internal flash memory and more storage of site information and map is not possible with this unit. Besides, with increasing number of projects in the division, more units (5 units for each project) are required for monitoring the seismicity at and around project site.

List of software

Sr. No.	Item	Type	TD	Probable Vendor	Cost in Rs.in Lakhs
1	EZ-Frisk,	Software	ES	1. Risk Engineering, Inc, 4155 Darley Avenue, Suit A Boulder, Colorado 80305	2.5

Justification

(i) A large set of attenuation equation is included with EZ-Frisk which can be adopted and extended as needed.

(ii) It can quickly perform analysis especially for location covered by our standard seismic source data base.

(iii) We can enter our own target spectrum, or use one based on a seismic hazard analysis uniform hazard spectrum.

It allows us to define our own fault and area sources and their seismic parameters

Instrumentation, Calibration and Testing Services (3 cr)

HARDWARE / SOFTWARE / LAB EQUIPMENT REQUIRED FOR INSTRUMENTATION, CALIBRATION AND TESTING SERVICES

Divisions : Hydraulic Machinery Calibration Laboratory, Current Meter Calibration, Random Sea Wave Generator, High Performance Computing (HPC) Laboratory, Coastal Data Collection

S. No.	Item	Type	Vendor	Cost in Rs. In Lakhs
1	Four Nos. isolation/control valves	L	1.Emersion (Fisher Valve), Mumbai 2 BDK Weir Valves, Hubli 3 Kirloskar Valves, Kirloskarwadi 4. KOSO Valves, Nashik	60
2	Electromagnetic flow meter(1000mm NB)	L	1. Krone Marshall, Pune 2 Endress + Hauser, Mumbai 3 ABB, India 4 Nivo Controls, Indore 5 Siemens, Germany	15
3	Repairing of CHT valves/Diverter and other systems	L	From India	20
4	Two Nos. motorized isolation valves	L	1. Emersion (Fisher valve), Mumbai 2. BDK Weir valves, Hubli 3. Kirloskar valves, Kirloskarwadi 4. KOSO valves, Nashik	5
5	Electromagnetic flow meter(200 mm NB)	L	1. Krone Marshall, Pune 2. Endress + Hauser, Mumbai 3. ABB, India 4. Nivo controls, Indore 5 Siemens, Germany	2
6	Non intrusive ultrasonic flow meter	L	1. Siemens, Germany 2. Endress + Hauser, Mumbai	30
7	Computational Fluid Dynamics (CFD) set up for pump intake model studies for vortex formation and pipeline transient flow analysis	S	FLOW 3D/ANSYS CFX computational fluid dynamics (CFD) software /Pro/ENGINEER® software	15
8	Upgradation of Test Rig for large pump in gravimetric laboratory	L	M/s TECHNOMECH, 22/3, Hadapsar, Industrial Estate Pune 411013 Ph # 26819617	12
9	Replacement / Renovation of DC and AC dynamometer and electrical control system	L / S	Leading Project Authorities like Coteba (India) Pvt Ltd (Elsewhile named as M/s Sogerah France), Kirloskar,Mather+platt, L&T, ABB etc can take project on turn key basis.	1250
10	Up gradation of CMRT	L / S	From India	60
11	Up gradation & Installation of	H/S	From India	50

	Random Sea Wave Generation System at CMRT			
12	Upgradation of existing RSWG facilities :	H/S/L	From India	400
13	Wireless Data Acquisition System for Dynamic Measurement of Wave Spectrum	L	From India	30
14	RTK ENABLED DGPS with Communication modules	F	M/s.Ashteck, France M/s. Leica, USA	10
15	Dual Frequency Echo sounder with GYRO and connectors	F	M/s. ODOM, USA M/s Reson, Denmark M/s. Kongsberg, Norway	35
16	Pre Processing Software	S	Clark Lab University, USA Geomatica, USA	5
17	Data Collection and Post Processing Software	S	M/s HYPACK, USA M/S. NAVISOFT	10
18	Centralized High Performance Computing (HPC) Laboratory	H/S/L	C-DAC, India	150
19	Directional Wave rider Buoy with GPS and solar panel system, Receiver & related software	F	1. M/s Datawell BV, Netherlands. 2. M/s Triaxys, Canada 3. M/s W.S.Ocean Syatems Ltd.,UK.	80
20	Calibration rig for Waverider Buoys.	CWP RS	1. Local firm.	5
21	In situ Current meters with related software	F	1. M/s Valeport, UK. 2. M/s Interocean systems, USA 3. M/s RDI Instruments, USA	30
22	In situ Directional wave & tide gauge with mooring cages and related software	F	1. M/s Valeport, UK. 2. M/s Interocean systems, USA 3. M/s RDI Instruments, USA	60
23	Depth measuring Equipment with Global Positioning System	F	1. M/s Bruttour International P. Ltd. Aus. 2. M/s Valeport, UK.	10

APPENDIX - D - Detailed List of Training Needs at CWPRS

Training Needs at CWPRS

This Appendix presents a detailed list of training needs for each discipline. Each discipline has been requested to prepare a detailed "wish" list for presentation and discussion during my second visit. A significant effort has been made by the leaders of each discipline and the needs are real. Each list has been prioritized with the highest priority item on top of the list. My own appraisal of the approximate sum that would be needed for each discipline for training purposes is presented in the summary table below. Suggested training sites and expert names are provided below.

<u>Summary</u>

River Engineering	2 cr
River and Reservoir Systems Modelling	2 cr
Reservoirs and Appurtenant Structures	2 cr
Coastal and Offshore Engineering	1 cr
Foundations and Structures	2 cr
Applied Earth Sciences	2 cr
Instrumentation, Calib. and Testing Services	3 cr
TOTAL	14 cr

River Engineering (2 cr)

III. TRAINING REQUIRED

A. Training Abroad

Sl.No.	Institution / Organization	Name of Expert	Areas of Training
1	Colorado State University, USA	Prof. Pierre Y. Julien, Department of Civil Engineering, Colorado State,University	Erosion & sedimentation, hydraulics, surface hydrology.
2	United States Bureau of Reclamation (USBR), USA		Environmental impact assessment - 2D modeling, water quality monitoring and improvement
3	Deltares, The Netherlands		Intake and Outfall systems - sedimentation
4	Artelia, France		Floods and natural hazards
5	United States Army Corps of Engineers (USACE), USA		Environmental Studies
6	IIHR - Hydroscience and Engineering, University of Iowa	1. Prof. George Constantinescu	CFD, River mechanics, turbulance, hydraulics
		2. Prof. A. Jacob Odgaard	Hydraulic modeling, environmental fluid mechanics, river engineering, river mechanics, steam erosion protection, etc.

B. In-house training from foreign experts

Sl.No.	Institution / Organization	Name of Expert	Areas of Training
1	University of Iowa	Prof. George Constantinescu	CFD, River mechanics, turbulance, hydraulics
2	Colorado State University, College of Engineering, USA	Prof. Ted Yang	Sediment transport, stream restoration, river hydraulics, computer modeling
3	NIT, Norway	Prof Nils Reider B. Olsen	Numerical modeling, fluid mechanics, CFD in hydraulic engineering
4	Norway University of Science and Technology	Prof. Jochen Aberle	Sedimentation and Sediment handling
5	San Diego State University, USA	Prof. Howard Chang	River and sedimentation engineering, hydrology for flood control, Fluvial 12
6	DELFT, The Netherlands	Prof. H. N. C. Breusers, G. Klaassen	Scour around bridge piers

River and Reservoir Systems Modelling (2 cr)

Training Details

A) Deputing Research Personnel Abroad for Specific Training:

Sl. No.	Level	Training Details	Advisor	Place	Period
1	Senior Management (1 No.)	Visits to Institutes – Facilities, capability, research areas covered and for collaborations		CSU, USA USU, USA IIHEE, Delft, Netherlands DHI, Denmark	5 days (Total)
2	Senior/ Middle Research (2 Nos.)	Advances in distributed modelling (processing of DEM and hydrologic processes), 2-D flow routing	Prof P.Y. Julien, CSU, USA Prof D.G. Tarboton, USU, USA	1 CSU, USA 2 USU, USA	3 months
3	Junior Research (2 Nos.)	River flood modelling, introductory level of distributed modelling aspects	Depends on the courses offered and decided by Institute	1 IIHEE, Delft, Netherlands 2 DHI, Denmark	3 weeks each
4	Senior / Middle Research	Concepts in modelling by using different software for Prediction of water quality of different types of water bodies including reservoirs		ASCE USGS DHI USEPA	One quarter / 3 months
5	Junior Research	1D model for predicting WQ scenario in river systems		DHI Denmark / CSU, USA/ IIHEE, Delft, Netherlands	5 days

CSU – Colorado State University;

USU – Utah State University;

IIHEE – International Institute of Hydraulic & Environmental Engineering;

DHI – Danish Hydraulic Institute;

ASCE – American Society of Civil Engineers;

USGS – United States Gelological Survey;

USEPA - United States Environmental Protection Agency

B) Inviting Experts to CWPRS

Sl. No.	Name, Institute and Country	Topic to be covered	Period
1	Prof Pierre Y. Julien, CSU, USA	Distributed modelling of hydrologic processes, 2D flow routing	5 days
2	Prof David G. Tarboton, USU, USA	DEM processing flow direction algorithms and flow modelling	5 days
3	Henrik Larsen, DHI Denmark,	A practical introduction to the fundamentals of Eco-Hydraulics to develop ecological model for predictions of water quality and aquatic ecosystem response.	5 days
4	Prof.Walter Rast, Prof Lopes Vincent, River Systems Institutes, Texas State University, USA	Lakes and Reservoir basin management tools for conservation of ecology and different models and GIS application	2 weeks

*Note:- The tentative cost as provided in inviting experts to CWPRS covers only travel from home country to Pune and back plus logistics of stay at Pune. It doesn't cover the consultancy fee to be charged by expert.

Reservoir and Appurtenant Structures (2 cr)

LIST OF TRAINING INSTITUTES AND EXPERTS

Sr. No.	Name of Institute/Expert	TD	Area	Duration
1.	Prof. Dr. Willi H. Hager V. Wasserbau, Hydrologie u. Glaz. ETH Zürich VAW E 37 Gloriastrasse 37/39 8092 Zuerich Phone: +41 44 632 41 49 E-Mail: hager@vaw.baug.ethz.ch	SED	Energy dissipators, Air water flow	2 weeks at CWPRS and One week at Lab in Zuerich
2.	George W. Annandale President, Engineering & Hydrosystems Inc. 8122 South Park Lane Suite 208 Littleton, Colorado United States 80120 Phone: +1 303 683 5191 Fax: +1 303 683-0940	SED	Scour downstream of ski jump bucket	2 weeks at CWPRS
3.	Prof. Hubert Chanson Department of Hydraulic Engineering and Applied Fluid Mechnics University of Queensland, Brisbane QLD 4072, Australia Tel: +61 73365 3516 Fax: +61 7 3365 4599 Email:h.chanson@uq.edu.au	SED	Turbulence measurement	2 weeks at CWPRS and One week at Lab in Australia
4.	Dr. David Zhu Professor, Water Resources Engineering, University of Alberta Canada T6G2W2 Phone: (780) 492-5813 Fax: (780) 492-0249 e-mail: david.zhu@ualberta.ca	SEDC SWCS SM	Turbulence measurement using PIV	2 weeks at Lab in University of Alberta
5.	Prof. John S. Gulliver St. Anthony Falls Laboratory |2 Third Avenue SE, Minneapolis, MN 55414 Office: CivE 110D SAFL 389 Phone: (612) 625-4080 Fax: (612) 626-7750 E-mail: gulli003@umn.edu	SED	Air water mass transfer and water quality	2 weeks at CWPRS
6.	Prof. Dr. Anton Schleiss EPFL ENAC IIC LCH GC A3 514 (Bâtiment GC) Station 18 CH-1015 Lausanne, Switzerland Phone: [+41 21 69] 32382, 32385 Email:anton.schleiss@epfl.ch	SED	Rock scour due to high velocity falling plunging jets downstream of spillways and bottom outlets	2 weeks at CWPRS

7.	Prof. Pierre Y. Julien Department of Civil and Environmental Engineering, Colorado State University, Colorado, USA Office Location: Engineering Research Center B203 Phone: (970)491-8450 Fax: (970)491-7008 Email: pierre@engr.colostate.edu	SM	Erosion and sedimentation	2 weeks at Institute in USA
8.	Tshinghua University International Technology Transfer Centre (ITTC) Contact: Mr. Zhang Yousheng, China Phone: +86 10 62792574 Fax: +86 10 62795182 Email: techtransfer@tsinghua.edu.cn	SED, CSW CS,S M	Erosion & Sedimentation	1 week at at Lab in China
9.	Subhas Karan Venayagamoorthy Assistant Professor Borland Professor of Hydraulics Department of Civil and Environmental Engineering Colorado State University, USA Office Location: Engineering A207A Phone: (970) 491-1915 Fax: (970) 491-7727 Email: vskaran@colostate.edu	SED, SM	Stratified Turbulence	1 week at CWPRS and One week at Lab in USA
10.	Mr. Yang Zhongmin State Key Laboratory of Advanced Technology for Materials Synthesis and Processing Wuhan University Luojia Hill, Wuhan 430072 China	SM	Sedimentation	1 week at CWPRS and One week at Lab in China
11.	Liu Chao College of Energy and Power Engineering Yangzhou University, Yangzhau 225127, China	SED, CSW CS, SM	Turbulence measurement using PIV	1 week at CWPRS + 1 week in China
12.	Prof. Michael Pfister Research & Teaching Associate EPFL ENAC IIC LCH GC A3 515 (Bâtiment GC) Station 18 CH-1015 Lausanne, Switzerland Email : michael.pfister@epfl.ch	SED	Air water flow analysis	2 weeks at CWPRS and One week at Lab in Lausanne
13.	HR Wallingford Howbery Park, Wallingford, Oxfordshire OX10 8BA, United Kingdom tel +44 (0)1491 835381 fax +44 (0)1491 832233 email: info@hrwallingford.com	SED, CSW CS, SM	Advance setup for lab instrumentation	One week at Lab in UK
14.	Professor Nils Reidar B. Olsen Department of Hydraulic and Environmental Engineering, NTNU S.P. Andersensvei 5 N-7491 Trondheim Norway	SM	Numerical modelling of hydropower reservoir flushing and desilting basin	2 weeks at Norway Institute in Norway
15.	The Yangtze River Scientific Research Institute 23 Huangpu Street, Wuhan, Hubei, 430010, P. R. China	SED, CSW CS, SM	Orifice Spillways, Desilting basin, Hydro elastic modelling of gates	Two weeks at Lab in China

	Tel: +86-27-82829793; Fax: +86-27-82829882 E-mail: yuling@public.wh.hb.cn			
16.	Prof. Lian Jijian, School of Civil Engineering, Tianjin University, China	SED, SM	Hydro elastic modelling of gates	Two weeks at Lab in China
17.	Laboratory of Hydraulics, Hydrology and Glaciology (VAW) Gloriastrasse 37 - 39 CH-8006 Zurich, Switzerland	SED, CSW CS, SM	Advance setup for lab instrumentation	One week at Lab in Switzer-land
18.	U.S. Army Engineer Research and Development Center (USAERDC) 3909 Halls Ferry Road Vicksburg, Mississippi 39180-6199 Telephone: 601-634-3188 Email: ceerd-pa-z@erdc.usace.army.mil	SED, CSW CS, SM	Advance setup for lab instrumentation and sediment transport analysis with HEC-RAS	One week at Lab, as per training programs for HEC-RAS
19.	Dr. Kuang Shang Fu, Director, China Institute of Water Resources and Hydropower Research Address: A-1 Fuxing Road, Beijing, P.R. China, Post Code:100038 email: webmaster@iwhr.com	SED, CSW CS, SM	Advance setup for lab instrumentation	Two weeks at Lab in China and one week at CWPRS
20.	Shailendra Sharan, Professor, School of Engineering, Laurentian Univ., ON, Canada,	CSW CS	Flow induced Gate vibration	2 weeks in Canada
21.	Kolkman P.A Delft Technical University, Civil Engineering Department, The Netherlands	CSW CS	Flow induced Gate vibration	2 weeks in Netherland

Long term Training

Long term training for studying Masters in Hydraulic engineering for the junior staff would be beneficial. The list of institutes for the same is as follows:

1. Colorado State University
   Fort Collins
   Colorado, 80523 USA
   Phone: (970) 491-1111
   www.colostate.edu
2. The University of Queensland
   Brisbane St Lucia, QLD 4072
   Australia
   Phone: +61 7 3365 1111
   www.uq.edu.au
3. ETH
   Swiss Federal Institute of Technology Zurich
   Main Building, Ramistrasse 101
   8092 Zurich
   Switzerland
   Phone: +41 44 632 1111
   Fax: +41 44 632 1010
   www.ethz.ch

4. University of Alberta
   116 St. and 85 Ave.
   Edmonton, AB, Canada T6G2R3
   Phone: 780-492-3111
   www.uofa.ualberta.ca

Coastal and Offshore Engineering (1 cr)

Advanced Training in US University (6 months)	T	CHS/ PH / MMCE	1) University of Florida 2) University of Texas
Short courses in Netherlands	T	CHS/ PH / MMCE	UNESCO – IHE/ TU-DELFT
Long Term Course in Netherlands (18 months)	T	CHS/ PH / MMCE	UNESCO – IHE/ TU-DELFT

Foundations and Structures (2 cr)

LIST OF INSTITUTES / EXPERTS FOR TRAINING- AT NATIONAL LEVEL

Sr. No.	Name of the Institute	Address	Type of Research	Name of expert	Duration of Course
1.	Structural Engineering Research Centre (SERC)	CSIR campus, Taramani, Chennai – 600 113	i. Structural Health Monitoring & Evaluation ii. Computational Structural Mechanics for analysis & design		1 – 2 Months
2.	Indian Institute of Technology	Roorkee- 247667, Uttarakhand	Dynamic stress analysis of gravity dams		1 – 2 Months
3.	Indian Institute of Technology	Pawai, Mumbai, Maharashtra	Dynamic stress analysis of gravity dams		1 – 2 Months
4.	Altair Pune	Pune	Application of HYPERWORKS FEM Software on stress analysis of gravity dams and other hydraulic structures.		1 Month
5	IIT Roorkee	Indian Institute of Technolog,y Roorkee Uttarakhand INDIA - 247 667	M.Tech in Soil Dynamics at Earthquake Engineering Division	-	18 months
6	IIT Bombay	Indian Institute of Technology Bombay Powai, INDIA	Elearning course on 'Soil Dynamics'	Dr. Deepankar Choudhury	
7	Itasca Consulting Group Inc.	Prayag Enclave Shankar Nagar, WHC Road Block 301, Plot #17 Nagpur 440 010 INDIA	Numerical Modelling for Nonlinear Dynamic analysis for earth and Rockfill dams using Software FLAC	-	1 month
8	National Institute of Rock Mechanics	Champion Reefs P. O.- Kolar Gold Fields – 563 117,Karnataka, India.	Blasting & Excavation Engg.,Rock Mechanics Instrumentation, Rock Testing and Rock Fracture Mechanics	Dr.H. Venkatesh, Mr. Sripad, Dr. G N Rao	1 – 2 Months
9	Central Soil and Material Research Station (CSMRS)	Ministry of Water Resources, Outer ring road, Olof Palme marg, Hauz khas, New Delhi – 110 016	Trainings are provided in areas of Numerical Modelling, In-situ stress evaluation, Monitoring the health of the existing structures	Institutional Head	1 – 2 Months

Sr. No.	Name of the Institute	Address	Type of Research	Name of expert	Duration of Course
10	IIT Kharagpur	Department of Mining Engineering,IIT Kharagpur - 721 302 (W.B.), India	Trainings are provided in areas of engineering behaviour of rock and rock masses in both mining and rock mechanics applications.	Institutional Head	1 – 2 Months
11	Itasca Consulting Group Inc.	Prayag Enclave Shankar Nagar, WHC Road Block 301, Plot #17 Nagpur 440 010 INDIA	Numerical Modelling for Nonlinear Dynamic analysis for earth and Rockfill dams using Software UDEC & 3DEC	-	1 month
12	Indian Institute of Technology	Chennai	Fibre Reinforced Concrete	Dr.Ravindra Gettu	1 – 2 Months
13	National Council of Cement & Building Materials	Hyderabad, New Delhi	Cement & Concrete Technology	Institutional head	1 – 2 Months
14	Structural Engineering Research Centre (SERC)	CSIR campus, Taramani, Chennai – 600 113	Fibre Reinforced Concrete & Polymer Concrete	Institutional head	1 – 2 Months
15	Indian Institute of Technology	Roorkee- 247667, Uttarakhand	Concrete Technology & Thermal Analysis of dams	Institutional head	1 – 2 Months
16	Indian Institute of Technology	Pawai, Mumbai, Maharashtra	Concrete Technology	Institutional head	1 – 2 Months
17	Centre for Advanced Concrete Research	SRM University, Kanchipuram, Tamil Nadu	Advanced Concrete Research	Shri. N P Rajamane	3 Months

Sr. No.	Name of the Institute	Address	Type of Research	Name of expert	Duration of Course
1.	Institute of Construction Materials	University of Stuttgart, Pfaffenwaldring 4, D-70569 Stattgart, Germany	Non-destructive examination & monitoring of structures with wireless sensor networks		6 Months – 1 year
2.	British Society for strain Measurement	London, UK	Stress & Load Analysis Course		1 -2 weeks
3.	Earthquake Engg Department	University of California, Berkeley, USA	Stress analysis of Hydraulic Structures		6 Months – 1 year
4	Pacific Earthquake Engineering Research Center (PEER)	California, Berkeley, USA	Fluid Structure Interaction		6 Months – 1 year
5	Pacific Earthquake Engineering Research Center (PEER)	California, Berkeley, USA	Earthquake Resistant Design		1 week
6	Pacific Earthquake Engineering Research Center (PEER)	California, Berkeley, USA	Fluid Structure Interaction	Prof. Medhat Haroun	1 week
7	Pacific Earthquake Engineering Research Center (PEER)	California, Berkeley, USA	Earthquake Resistant Design	Prof Steve Mahin	1 week
8	MS in Structural Engineering, Mechanics and Materials	University of California Berkeley	Higher qualification		1 -1.5 year
9	Quest Structures	Quest Structures Inc, 3 Altarinda Road, Suite 203 Orinda, CA 94563 USA	Training in dam, structural, earthquake engineering	Y Ghanaat	1 week
10	The University of New South Wales, SYDNEY,NSW 2052 AUSTRALIA	The School of Civil and Environmental Engineering The University of New South Wales, SYDNEY, NSW 2052 AUSTRALIA	Stability Analysis Of Large Dams	S. Valliappa n	1 week
11	Technical Service Center, Geotechnical Services (USBR)	Instrumentation and Inspections Group DeWayne Campbell, Manager, 303-445-3052 Building 67, 86-68360 Denver Federal Center, Denver, Colorado 80225-0007	Instrumentation and inspection related services for dams		1 Month

Sr. No.	Name of the Institute	Address	Type of Research	Name of expert	Duration of Course
12	Delft University of Technology, Netherlands	Geo Engineering Section PO Box 5048 2600 GA Delft The Netherlands	Undergoing Course for acquiring higher qualification (MSc-Geotechnical Engineering)	Institutional Head	2 years
13	Norwegian university of Science & technology	Dept of Civil & Transporation Engineering NO 7491, Trondhiem Norway	Undergoing Course for acquiring higher qualification (MSc-Geotechnics and Geohazards)	Institutional Head	2 years
14	Norwegian university of Science & technology	Dept of Civil & Transporation Engineering NO 7491, Trondhiem Norway	Undergoing following Training courses 1) Geotechnical Engineering, Advanced Course 2) Soil Modelling 3) Finite Elements in Geotechnical Engineering	Steinar Nordal	1 month
15	University of Berkeley	Civil & Environmental Engineering University of Berkeley California	Undergoing Training course on 'Numerical Modelling in GeoMechanics'	-	6 months
16	University of Berkeley	Civil & Environmental Engineering University of Berkeley California	Undergoing Training course on 'Geotechnical Earthquake Engineering'	-	6 months
17	ROSE SCHOOL	c/o EUCENTRE Via Ferrata, 1 - 27100 Pavia, Italy	Short Course on 'Numerical Modelling in Geotechnical Engineering'	-	1 week
18	McMaster University	McMaster University 1280, Main Street W Hamilton, ON, L8S 4L8	Numerical Modelling in Geotechnical Engineering	Dr. D. F. Stolle Dr. Peijun Guo	15 days - 1 month
19	University of Toronto	University of Toronto Department of Civil Engineering University of Toronto 35 St. George Street Toronto, ON M5S 1A4 CANADA	FLAC Modelling for Soils	Dr. Jim Hazzard	15 days - 1 month

Applied Earth Sciences (2 cr)

Sr no	Name of the Institute	Address for correspondence	Nature of Research	Name of experts
1	National Geophysical Research Institute (NGRI)	National Geophysical Research Institute Uppal Road, Hyderabad- 500606 Andhra Pradesh, India. Fax : +91 40 27171564 Phone: +91 40 23434700, 23434711	Electro-magnetic Method of Geophysical Exploration	Dr. S.K. Verma**
2	Indian Institute of Technology Delhi (IIT Delhi)	Department of Civil Engineering Indian Institute of Technology Delhi Hauz Khas, New Delhi-110 016, INDIA Tele: (91) 011-2659 1999, (91) 011-2659 7135 Fax: (91) 011-2658 2037, (91) 011-2658 2277 Email:raoks[at]civil.iitd.ac.in	Multi channel analysis of surface waves	Dr. K.S.Rao** Professor
3	Indian Institute of Science, Bangalore	Department of Civil Engineering Indian Institute of Science Bangalore 560 012, INDIA Telephone: 080-2293 2467 E mail: anbazhagan@civil.iisc.ernet.in Fax : +91 - 80 - 2360 0683/0085	Multi channel analysis of surface waves	Anbazhagan P ** Assistant Professor
4	Indian Institute of Science, Bangalore	Department of Civil Engineering Indian Institute of Science Bangalore 560 012, INDIA Telephone: 080-2293 2329; 2360 2261 E mail: sitharam@civil.iisc.ernet.in Fax : +91 - 80 - 2360 0683/0085	Multi channel analysis of surface waves	Sitharam T G ** Professor
5	National Geophysical Research Institute (NGRI)	National Geophysical Research Institute Uppal Road, Hyderabad- 500606 Andhra Pradesh, India. Fax : +91 40 27171564 Phone: +91 40 23434700, 23434711	Application of Electrical Method in Geophysics	Dr. T.Seshunarayana**

Sr No.	Name of the Institute	Address for correspondence	Nature of Research	Name of experts	Duration of Course
National					
6	National Geophysical Research Institute (NGRI)	National Geophysical Research Institute Uppal Road, Hyderabad-500606 Andhra Pradesh, India. Fax : +91 40 27171564 Phone: +91 40 23434700, 23434711	Seismic refraction and reflection	Dr. T.Seshunarayana**	4-8 weeks
International					
1	The University of New South Wales	School of BEES, UNSW Sydney NSW 2052 Australia Phone: +61 (02) 9385-8719 Fax: +61 (02) 9385-1558 Email: d.palmer@ unsw.edu.au	Generalized Reciprocal Method (GRM) of Seismic refraction interpretation	Derecke Palmer*	8 weeks
2	Department of Earth Sciences, Uppsala University	Department of Earth Sciences., Uppsala University, Villavägen 16, SE-752 36 Uppsala, Sweden	Seismic refraction data processing and interpretation	B. Sjogren*	8 weeks
3	Geophysical Survey Systems, Inc	Geophysical Survey Systems, Inc Address: 12 Industrial Way, Salem, NH 03079 Telephone Number: 603-893-1109 Fax Number: 603-889-3984	Advancements in Ground penenetrating radar applications	Geophysical Survey Systems, Inc*	8 weeks
4	Kansas Geological Survey	Rick Miller Senior Scientist, Exploration Services Section, Kansas Geological Survey 1930 Constant Avenue University of Kansas Lawrence, KS 66047-3726 Phone: 785-864-2091 FAX: 785-864-5317 e-mail: rmiller@kgs.ku.edu	Multi channel analysis of surface waves	Rick Miller* Park	8 weeks
	Current senior staff - 1 Current Junior Staff – 5 *: Name of the expert will be finalized after further communication with the Institutes **: Name of the expert for training at CWPRS, Pune will be finalized after further communication with the expert				

Sr. No	Name of Institute	Address	Type of Research	Name of Expert	Duration of Course
NATIONAL					
1	I.I.S.C Bangalore, Dept. Civil Engineering	Gulmohar Marg, Near-Centre For Neroscience, Mathikere, Bangalore, Karnataka 560012	*Isotope Hydrology*	Prof. M S Mohan Kumar	8-12 weeks
2	N.G.R.I Hyderabad, Dept: Groundwater Replenishment	Uppal Road, Hubsiguda Secunderabad - 500007	*Isotope tracer studies*	Dr. Rangarajan R	4-8 weeks
3	N.I.H, Roorkee	Scientist `F' and Head HI Division, PI-IWIN (national) Project at NIH Roorkee	*Isotope Hydrology*	Dr.Bhishm Kumar	4-8 weeks
4	C.W.R.D.M, Kozhikode, Kerala	Centre for Water Resources Development and Management Kunnamangalam, Kozhikode-673 571 , Kerala	*Stable and radioactive isotopes*	Dr. A. Shahul Hameed	4-8 weeks
5	B.A.R.C, Mumbai	IARP, C/O RPAD, CT&CRS, Anushaktinagar, BARC, Mumbai	*Nucleonic Gauges*		4-8 weeks
1	Nuclear Decommission ing Authority, UK	Nuclear Physics Division, Atomic Energy Research Establishment, Harwell, Didcot, Oxon, OX11 0RA, U.K.	*Radioisotope Techniques*	G.V. Evans	6-8 months
2	K.U.F.A University, Arabia	College of Engineering, Kufa Unirvesity, Iraq	*Hydraulics*	Dr.Saleh I. Khassaf Al-Saadi	6-8 months
3	T.A.M.U Texas A & M University	Department of Biological and Agricultural, Engineering 321 Scoates Hall ; 2117	*Isotope Studies*	Prof. Vijay P.Singh.	6-8 months
4	B.R.G.M - France	Water Department 1039 rue de Pinville 34000 Montpellier FRANCE	*Isotope Hydrology*	Jean-Christophe MARECHAL	6-8 months
5	RADIATION CONSULTAN T, Deer Park, Texas, USA	P.O. Box 787 2017 Westside Dr. Deer Park, TX 77536 USA	*Well Logging*		2 weeks

6	U.N.E.S.C.O-IHE, Institute for water education	UNESCO-IHE PO Box 3015 2601 DA Delft The Netherlands	*Isotope Hydrology*		2 weeks
7	TECHNOLOGY EXPERTS (Global Expert Group), Saudi Arabia	Head Office - Riyadh P. O. Box 361301, Riyadh 11313, Riyadh	*Well Logging*		2 weeks
8	I.A.H (International chapter)	IAH Secretariat, PO Box 4130, Goring, Reading, RG8 6BJ United Kingdom	*Isotope studies*		2 weeks
9	American Society of Civil Engineers	1801 Alexander Bell Drive Reston, VA 20191	*Dam Engineering*		2 weeks
10	National Ground Water Association	601 Dempsey Rd. Westerville, OH 43081 USA 800 551.7379	*Water Hydraulics*		2 weeks
11	University of Waterloo	Department of Earth & Environmental Sciences 200 University Ave. W Waterloo, Ontario, Canada N2L 3G1	*Isotope studies*		2 weeks
12	Princeton Groundwater, Inc	Princeton Groundwater, Inc. P.O. Box 273776 Tampa, Florida 33688, USA	*Isotope Studies*		2 weeks
13	Schlumberger water Services	Oak Environmental 103-4712 - 13 Street NE Calgary Alberta T2E 6P1 Canada	*Modelling software for well logging*		2 weeks
14	National centre for Groundwater Research & training	School of the Environment Flinders University GPO Box 2100 Adelaide SA 5001 Australia	*Modelling software*		2 weeks

Sr. No.	Name of The Institute	Address	Type of Research	Name of Expert*	Duration of Course
National					
1.	Structural Engineering Research Centre (SERC)	CSIR campus, Taramani, Chennai – 600 113 rams@sercm.res.in Tel.: 04422549198	Vibrations and NDT of civil structures	Dr K. Ramanjaneyulu, Sr. Principal Scientist	2 to 3 weeks
2.	Indian Institute of Technology, Roorkee	Dept. of Earthquake Engg. Roorkee- 247667, Uttarakhand dpaulfeq@iitr.ernet.in Ph.: 01332-285522 dubeyfeq@iitr.ernet.in, Ph.: 01332-285537	Vibration studies	Dr.D.K. Paul or Dr.R.N. Dubey	2 to 3 weeks
3.	Indian Institute of Technology, Mumbai	Dept. of Civil Engg. Powai, Mumbai - 400076 pbanerji[at]civil.iitb.ac.in, Ph.: 022 2576 7334 agoyal@civil.iitb.ac.in, Ph.: 022 2576 7342	Vibrations and NDT of civil structures	Prof. P. Banerji Or Prof. A. Goyal	2 to 3 weeks
4.	National Institute of Rock Mechanics	Champion Reefs P. O. Kolar Gold Fields - 563 117, Karnataka Ph.:08153-275 004-009 Fax : 08153-275002	Controlled Blasting	Dr. S Venkatesh, Scientist-V Or Mr AI Theresraj, Scientist-II	2 to 3 weeks
5.	Central Mining and Fuel Research Institute	Environmental Management Barwa Road, Dhanbad -826001 Mobile: 9431541940 cramcimfrdc@gmail.com	Controlled Blasting	Dr. L. C. Ram, Sct. F & Head	2 to 3 weeks
6.	Indian School of Mines	Mining Dept. Dhanbad - 826004, Jharkhand vmsr_murthy@yahoo.com Ph.: 0326 2235445	Controlled Blasting	V. M. S. R. Murthy, Professor	2 to 3 weeks
International					
1. BAM – Federal Institute for Materials Research & Testing Berlin, Germany Non-destructive testing of civil structures Dr. Herbert Wiggen-hauser 10 to 12 weeks 2. NDT Training School Texas, Birring NDE Center, Inc., 515 Tristar Drive, Suite A, Webster, TX 77598, USA Vibration studies of civil structures Stephanie Navarro 10 to 12 weeks					

Sr. No.	Name of the Institute	Address	Type of Research	Name of expert*
International				
1.	USGS (U.S. Geological Survey)	USGS Headquarters (Virginia) USGS National Center 12201 Sunrise Valley Drive Reston, VA 20192, USA Phone: 703-648-5953	Earthquake Hazards Program	David Applegate Kevin Gallagher
2.	USGS (U.S. Geological Survey)	Denver Federal Center (Colorado) U.S. Geological Survey Box 25046 Denver Federal Center Denver, CO 80225, USA Phone: 303-202-4200	Study of earthquakes around the world and regional seismic network monitoring, and local activities of interest.	William F Horak
3.	USGS (U.S. Geological Survey)	Menlo Park (California) U.S. Geological Survey 345 Middlefield Road Menlo Park, CA 94025, USA Phone:650-853-8300	Study of earthquakes around the world and regional seismic network monitoring, and local activities of interest.	Thomas M Brocher
4.	International Institute of Seismology and Earthquake Engineering (IISEE)	International Institute of Seismology and Earthquake Engineering, Building Research Institute, 1 Tatehara, Tsukuba, Ibaraki 305-0802, Japan E-mail: iisee@kenken.go.jp	Study on Strong Motion Observations on structures. Aftershock Distributions, Fault planes, and Rupture processes for large earthquakes	Dr. FUJII, Yushiro Dr. HARA, Tatsuhiko Dr. SHIBAZAKI, Bunichir

Sr. No.	Name of Expert	Type of Research	Duration
I			
1.	**Dr. Anil K. Chopra**, Department of Civil and Environmental Engineering, University of California, Berkley, CA 94720-1710, USA	Earthquake analysis of concrete dams	One week
II			
1.	Prof. **Mihailo D. Trifunac** University of Southern California Civil Engineering Department, KAP 216D Los Angeles, CA 90089-2531 Phone No. (213) 740-0570; Fax: (213) 744-1426; E-mail: trifunac@usc.edu	Seismology/Earthquake Engineering	One to two week
2.	Prof. **David M Boore** U.S. Geological Survey 345 Middlefield Road, Mail Stop 977 Menlo Park, CA 94025 Phone No. 650-329-5616 Fax: 1-650-329-5163 E-mail: boore@usgs.gov	Seismology/Earthquake Engineering	One to two week
3.	Prof. Julian J. Bommer Civil and Environmental Engineering ,Imperial College ,London SW7 2AZ, UK Phno.+44(0)2075945984 FAX no. Email: j.bommer@imperial.ac.uk	Seismology/Earthquake Engineering	One to two week
4.	**The University of Auckland** Private Bag 92019 Auckland 1142, New Zealand Phone: 923 7020 (within Auckland) 0800 61 62 63 (outside Auckland) +64 9 373 7513 (overseas) Fax: +64 9 373 7431 E-mail: scifac@auckland.ac.nz	Seismology/Earthquake Engineering	3-12 months
1.	**University of Southern California** Office of the President Emeritus University of Southern California 3551 Trousdale Parkway, Administration 300 Los Angeles, California 90089-4011 Phone: (213) 740-5400 Fax: (213) 740-5454	Seismology/Earthquake Engineering	3-12 months
2.	**Norwegian Geotechnical Institute (NGI)** NGI, P.O. Box. 3930 Ullevål Stadion, N-0806 Oslo, Norway **Ph no.:** +47 22 02 30 00 **E-mail:** ngi@ngi.no,	Seismology/Earthquake Engineering	3-12 months

Instrumentation, Calibration and Testing Services (3 cr)

TRAINING REQUIRED FOR INSTRUMENTATION, CALIBRATION AND TESTING SERVICES

Divisions: Hydraulic Machinery Calibration Laboratory, Current Meter Calibration, Random Sea Wave Generator, High Performance Computing (HPC) Laboratory, Coastal Data Collection.

Sr. No.	**Topic of Research**	**Name of Institute**	**Duration of Course**
1	i) Parallel/independent Operation of both test line ii) Calibration under non-standard installation conditions	Fluid Control Research Institute, Pallakkad, Kerala, India	2 -3 weeks
2	Cavitation in Fluid Machinery and design of research facilitiesfor cavitation and hydroacoustics	**1**. Prof. Roger EA Arndt University of Minnesota, USA 2. Prof. Paul Brandner, Australian Maritime College's Cavitation Research Lab 3. Prof. Mehmet Atlar Emerson Cavitation Tunnel ,UK	2 weeks
3	Cavitation in Fluid Machinery and design of research facilities for cavitation and hydroacoustics	1. Australian Maritime College(AMC),Aus. 2. Emerson Cavitation Tunnel School of Marine Science and Technology, Univ. Newcastle, UK 3. M A R I N , P.O. Box 286700 AA Wageningen Netherlands 4. St. Anthony Falls Laboratory,Minneapoli, USA	2- 3 weeks
4	DGPS Control & Operation	M/s. Ashteck, France M/s Leica, USA	2 - 3 weeks
5	*Echosounder Control & Operation*	M/s. ODOM, USA M/s Reson, Denmark M/s. Kongsberg,Norway	2 - 3 weeks
6	*Preprocessing Imageries and Graphics*	Clark Lab University, USA Geomatica, USA	2 - 3 weeks

7	*Data Logging and Processing*	M/s HYPACK, USA M/S. NAVISOFT	
8	Directional Waverider Buoy With GPS & software. Calibration & maintenance.	M/s Datawell BV, Netherlands.	2 weeks 1 – 2 Months
9	In situ Current meters, In situ Tide gauge Calibration & maintenance.	M/s Valeport, UK.	2 weeks 1 – 2 Months
10	Acoustic Doppler Current profiler	M/s RD Instruments, France/ USA	2 weeks 1 – 2 Months
11	Waverider Buoy Calibration & maintenance.	National Institute of Ocean Technology, Chennai.	1 – 2 Months