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Stakeholder evaluation of the feasibility of watershed management alternatives, using Integrated Lake Basin Management principles

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Abstract

Containing more than 90% of the liquid fresh water on our planet's surface, lakes are used for a wide range of human needs. Managing them for sustainable use also requires consideration of a multitude of scientific, socioeconomic and governance issues. Integrated Lake Basin Management (ILBM) is a comprehensive approach for achieving sustainable management of lakes and reservoirs through gradual, continuous and holistic improvement of basin governance, involving sustained efforts for improvement of six governance 'pillars' (Policy; Institutions: Stakeholders; Knowledge; Technology; Finances). This study demonstrates that ILBM is applicable not only to lentic water systems (lakes, reservoirs), but also to the upstream and downstream water systems (rivers, tributaries) of which they are a part. Two watersheds in eastern Pennsylvania (USA), designated as 'Critical Water Planning Areas,' are used as a case study for this application, with a focus on the ILBM Stakeholder pillar. The primary objective was to rank the feasibility of alternative management options for these watersheds on the basis of watershed stakeholder perceptions and discussions. The results of this process and the analyses undertaken in this study are discussed, including the management options ultimately identified, the lessons learned in the evaluation process, and means for improving the process for future evaluations.

Key words

basins, governance, integrated management, lakes, rivers, stakeholders.

INTRODUCTION

Lakes, which contain more than 90% of all the readily available liquid fresh water on the surface of our planet, are used for a wide range of life-supporting ecosystem goods and services (e.g. drinking water supply, agricultural irrigation, fisheries, recreation, transportation, hydropower generation). Accordingly, they also are the water bodies most likely to experience water use conflicts. Experience around the world, however, has highlighted the fact that the effective management of lakes for sustainable use is a complex undertaking, requiring consideration of a multitude of scientific, socio-economic and governance issues.

Recognizing these requirements, the International Lake Environment Committee Foundation (ILEC) developed a comprehensive lake assessment and management approach, called Integrated Lake Basin Management (ILBM). This approach focuses on considering relevant scientific, socio-economic and governance components for the purpose of managing lakes for their sustainable use (Nakamura & Rast 2011). More specifically, ILBM is an approach for achieving sustainable management of lakes and reservoirs by gradual, continuous and holistic development and improvement of six elements ('pillars') of basin governance, including (i) Policy directions; (ii) Institutional responsibilities; (iii) Stakeholder participation; (iv) Scientific and traditional knowledge; (v) Technological considerations; and (vi) Funding prospects and constraints. In general, ILEC proposes the development and improvement of the governance 'pillars' through collective stakeholder actions as a strategic means of

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facilitating the gradual and continuous improvement of basin governance over a long time period.

It can readily be argued that most environmental degradation and over-exploitation can be attributed to governance failures of some type. The ILBM focus on these elements, therefore, makes the approach relevant not only for lake management purposes, but also for the management of other freshwater systems, including river basins and aquifers. This relevance is further supported by the observation that the ILBM approach also considers the hydrological links between lakes, rivers and groundwater systems in its application. In short, although ILBM was developed for lake management purposes, the experience to date suggests this approach can be considered for application to other freshwater systems as well, particularly in regard to governance issues.

Accordingly, this study focuses on demonstrating the use of ILBM to facilitate stakeholder evaluation of a range of management alternatives for the Rock and Marsh Creek watersheds in eastern Pennsylvania (USA). The main objectives of this study were to

1. Work with key stakeholders within the Rock and Marsh Creek watersheds to create a list of management alternatives believed capable of solving previously identified issues in these watersheds.
2. Develop a prioritized list of management options based on stakeholder evaluation of their feasibility, through consensus-based rating of the ILBM governance pillars.
3. Compile and disseminate information on the issues encountered with the use of this stakeholder participation-based management process, as well as their resolution, for the purpose of informing future watershed managers.

STUDY AREA

This study focuses on the Rock and Marsh Creek watersheds in Adams County, located on the southern border of Pennsylvania in the eastern United States (Fig. 1; Interstate Commission on the Potomac River Basin (ICPRB) 2011). As part of Pennsylvania Act 220, requiring investigation of Pennsylvania's water resources and development of a state water management plan, the combined Rock and Marsh Creek watersheds were subsequently designated, a 'Critical Water Planning Area' (CWPA), defined as a '*significant hydrologic unit where existing or future demands exceed, or threaten to exceed, the safe yield of available water resources*' (Department of Environmental Protection (DEP) 2006). The two watersheds were combined in this designation because they are hydrologically connected, as the headwaters to the Potomac River basin (providing water supply to Washington, D.C.), and because the populated area surrounding the borough of Gettysburg lies in both watersheds, resulting in their each exhibiting similar water withdrawal (e.g. wells drying up) and pollution issues (Department of Environmental Protection (DEP) 2009).

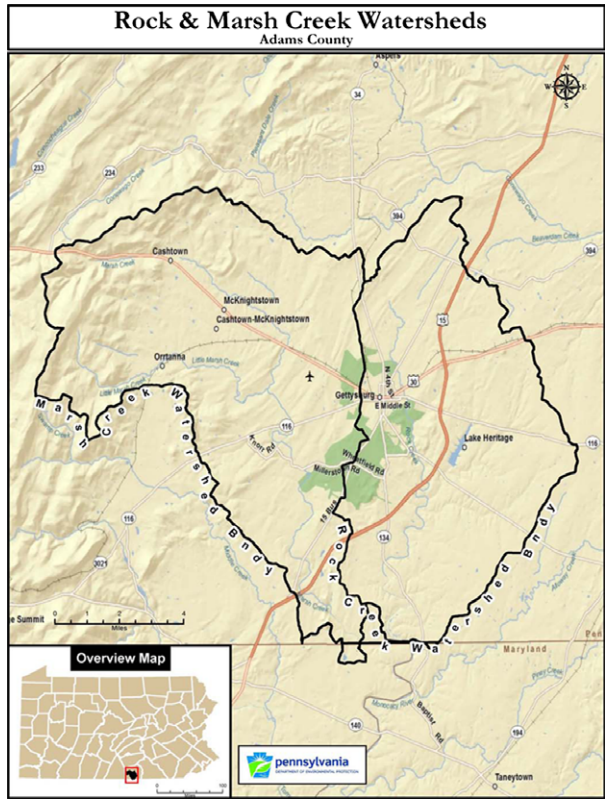

Fig. 1. Location of Rock and Marsh Creek watersheds in southeastern Pennsylvania, USA (Department Environmental Protection (DEP) 2009).

CONTEXT OF STUDY

With the CWPA designation, the Marsh and Rock Creek watersheds were required to develop a Critical Area Resource Plan (CARP) consistent with the Act 220 guidelines. The Interstate Commission on the Potomac River Basin (ICPRB) was then contracted to assist in these efforts, subsequently developing several steps necessary to complete the process (Fig. 2; Interstate Commission on the Potomac River Basin (ICPRB) 2012). The first six steps of the CARP process were completed by ICPRB prior to initiation of this study.

The first of these steps was to develop a Critical Area Advisory Committee (CAAC) which, upon completion, consisted of all relevant watershed stakeholders, including representatives of each school district and university within the watershed (total of 9 individuals); all munici-

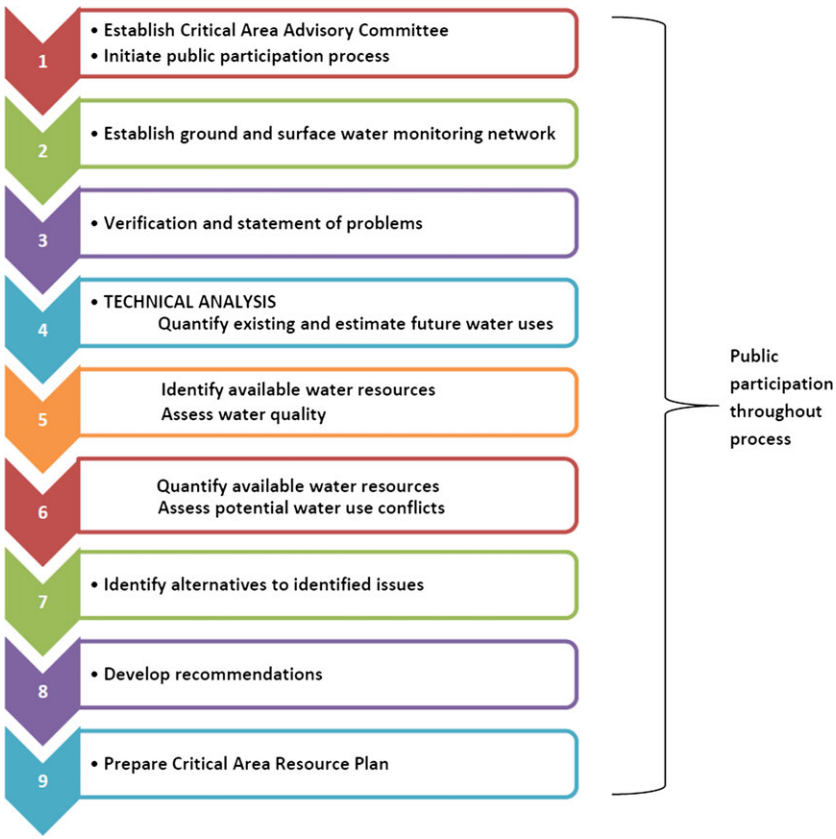

Fig. 2. Nine steps to develop Critical Area Resource Plan (CARP) for Rock and Marsh Creek watersheds (each check mark indicates a step completed prior to initiation of present study; Interstate Commission on the Potomac River Basin (ICPRB) 2011).

palities (13); state elected officials (4); federal officials (1); conservation/environmental groups (4); public water suppliers (2); county planning offices (5); all agriculture sectors (cattle; wineries; orchards; total of 7); major industries (3); developers (1); and others with knowledge of the study site (4). The specific organizations and agencies represented in this group were previously identified by Saunders (2013).

The ICBRP also (i) established the groundwater and surface water monitoring network (CARP Step 2); (ii) verified and developed a statement of problems (CARP Step 3); and (iii) completed the technical analyses (CARP Steps 4 through 6). Each of these components was then used to inform the CAAC (the ultimate decision-makers) and was used as reference materials for this study.

Examining the process used by ICPRB to create the CARP indicates it used the key concepts and steps necessary to create a truly collaborative (and potentially adaptive) management framework, being loosely defined as a governance system, whereby multirepresentative stakeholders facilitate learning and contribute to a more comprehensive, interactive decision-making process (Innes & Booher 2010). ICPRB also worked to satisfy the criteria needed for successful collaborative management projects (McNeil *et al.* 2006; Ansel & Gash 2007; Susskind *et al.* 2012), including:

1. Trust among stakeholder groups.
2. Continuous key stakeholder group involvement in the decision-making process.
3. Support from the scientific community for consultation, but not decision-making.
4. Clear and systematic guidelines on how to proceed.

This study focuses on Step 7 of the CARP process ('Identify Alternatives to Identified Issues'; Fig. 2), being designed to systematically identify and assess options for effective basin-scale management of the Rock and Marsh Creek watersheds. It was conducted in collaboration with Corazón de la Tierra (a nongovernmental organization focusing on the Lake Chapala–Lerma River Basin in Mexico), ICPRB, Pennsylvania Department of Environmental Protection (DEP), and the Marsh and Rock Creek CAAC.

METHODOLOGY

When selecting and further developing the methodology in this study, it was important the methodology meet the

following criteria: (i) it was clear, systematic and logical, particularly for nonscientific audiences (i.e. many of the CAAC members); (ii) it used CAAC expertise effectively to help build consensus on the management alternatives ultimately selected for the CARP; and (iii) it contributed further to the work already completed by ICPRB in creating the CARP through a truly collaborative process. With these criteria, the methodology developed by Corazón de la Tierra on the basis of the ILBM framework (Nakamura & Rast 2011) was determined to be the most appropriate methodology for this study. Additional rationale was that this methodology was previously demonstrated to be useful in analyses of three sub-basins in the Lake Chapala drainage basin in Mexico (Juaréz-Aguilar 2011) and could be easily adapted for the purposes of this study.

The original methodology, as developed by Corazón de la Tierra, utilized stakeholder workshops to build consensus via a series of questions meant to evaluate the current overall status of watershed management in several sub -basins. The steps used in the original methodology are further described by Juaréz-Aguilar (2010A &) Juaréz-Aguilar (2010B) and were modified to address the needs of the Rock and Marsh Creek study area. This resulted in the following six specific steps being conducted between October 2011 and April 2012.

Step 1: Ensure all stakeholders have a common background and knowledge

As this study required intensive consultation with individuals of highly varied backgrounds (i.e. CAAC members) on watershed management alternatives, it was necessary to lay the groundwork for productive discussions. This preparation involved two components, the first being to ensure all CAAC members were educated on 'what watershed management is'. The second was to educate the stakeholders on the major issues in their watershed, based on the technical analyses completed by ICPRB prior to this study. Each component is described further below.

Watershed management educational meeting

An initial meeting conducted on 12 October 2011 was used to explain the conduct of the study, how it could benefit the group, and to provide background information on '*what watershed management means*'. As noted above, the ILBM framework was utilized as a tool to explain relevant watershed management concepts because:

1. It was intuitive, easy to explain and readily understood.
2. It had readily available training materials and publications CAAC members could refer to throughout the process.
3. It had previously proven to be an effective framework for various lake basins around the world (Kodarkar *et al.* 2009; International Lake Environment Committee (ILEC) 2005).
4. It was applicable to both lake and river basin management.
5. It included an explanation of the six ILBM pillars (Policies; Institutions; Stakeholder engagement; Information needs; Technology; Finances; International Lake Environment Committee (ILEC) 2005), which would subsequently be used to evaluate the feasibility of watershed management alternatives (see Methodology Step 3).

This 'educational process' was followed by a discussion and subsequent vote on whether or not the CAAC was interested in utilizing this proposed study in the CARP planning process. The vote was positive; thereby ensuring active CAAC participation in the present study, as well as increasing the likelihood the CAAC would accept the study results.

This education process was also enhanced by posting all information and ILBM electronic links on the CWPA blog, which was created for within-CAAC communication and for Rock and Marsh Creek community members. The CAAC also was encouraged to further research these and other relevant issues after the completion of the workshop.

Dissemination of materials explaining Rock and March Creek watershed issues

To assure every CAAC participant was fully aware of the issues applicable to the Rock and Marsh Creek watershed (Table 1), a summary of the previously completed ICPRB studies was compiled and distributed to all participants. Questions and discussion were encouraged, resulting in several private meetings, online chats, e-mail correspondences and telephone conversations.

Step 2: Develop a list of management alternatives

A meeting was conducted on 11 January 2012 to develop a list of management options the CAAC believed were needed to solve the previously identified problems (Table 1). A list of previously collected management options was distributed prior to the meeting, with the committee being requested to add any additional management options deemed important. This resulted in a list of 44 options CAAC members believed could be implemented to solve the watershed issues. The merits of each

Table 1. Summary of issues identified through Interstate Commission on the Potomac River Basin and Critical Area Advisory Committee studies and discussions (Interstate Commission on the Potomac River Basin (ICPRB) 2012)

Issue summary
Excessive water withdrawal: The average quantity of water withdrawn daily in each CWPA subwatershed in every season is greater than low flow conditions represented by 7Q10†. Future growth is expected to exacerbate this problem, with an average maximum expected increase of 67% by 2030.
Limited water storage capacity: As a result of natural and anthropogenic conditions in the watersheds, water storage is limited. The 13 public water suppliers have a total reported storage capacity of 3 842 570 gallons (as of 2004), representing 2.3 days of average use. This issue is not limited to public water suppliers, being pervasive throughout the watersheds.
Degraded water quality: As impaired waterways exist throughout CWPA, actions taken in the watersheds should strive to maintain and/or improve existing water quality conditions to prevent costly impacts to water users.
Storm water run-off: Uncontrolled storm water run-off affects Marsh and Rock Creek water quality (sediments, nutrients, erosion). Regarding storm water quantity, sufficient storm water is available to meet water deficits in all seasons for the CWPA.
Inadequate management: Lack of integrated, coordinated oversight and management of water resources at the CWPA scale, including authority for implementation (due to regulatory limitations at the state/county level)
Inadequate data: Data availability is a concern for managing water resources in the Marsh and Rock Creek watersheds, with a significant portion of the water used in the Marsh and Rock Creek watersheds is currently estimated because of inadequate reporting of water uses, although limited long-term surface and groundwater level and quality data are available.

†7Q10 refers to the lowest 7-day average flow occurring (on average) once every 10 years.

alternative were not discussed at this specific workshop, but rather was the subject of a subsequent workshop.

Step 3: Preliminary analysis and communication of management alternatives

To facilitate discussion of the management options, to be conducted in Step 5 of this methodology, a preliminary analysis of each alternative was distributed to the CAAC for review. This step was completed to ensure all CAAC members understood each management alternative, and its requirements. The preliminary analysis included an explanation of each management option, the approximate cost associated with them and a preliminary idea of how it could help better manage the watershed. This document was distributed via email and posted on the CWPA blog. Discussions and questions were again encouraged with the distribution of the analysis.

Step 4: Development of questions meant to evaluate feasibility

To prepare for the next workshop, to seek CAAC consensus on the feasibility of different management options (Methodology Step 5), six questions were developed in collaboration with ICPRB (Table 2). This collaboration was included in the methodology in order to ensure the development comprehensive and meaningful questions as well as to ensure that leading questions were avoided. Each developed question was based on one of the six ILBM governance pillars, and phrased in a manner relevant to CAAC and CARP goals. Given that Act 220 guidelines emphasized the need for voluntary management alternatives, the questions were written specifically to reflect the feasibility of each management alternative within this context. Consequently, the question relating to the technology pillar was transformed to a timeframe question, based on the logic that a more extensive technological fix would require more time to complete and therefore be less feasible when being completed on a voluntary basis.

The defined responses for each developed question were completed in a gradient, with clear, succinct wording, according to social science research protocol (Singleton & Straits 2005; Podsakoff *et al.* 2012), to avoid misunderstanding and bias. Additionally, to provide the opportunity for quick responses to each question, five scores (either 0, 3, 5, 7 or 10) were assigned to each of the defined responses provided for the developed questions. The lowest scores were given to responses which were deemed 'the least feasible'. In the 'Technology Pillar', for example the management techniques which required long-term time commitments (i.e. 20+ years) were given the lowest score of zero, while the shorter term projects (i.e. less than a year) were given the highest score of ten. The developed scoring system, as well as the response associated with each score, is also shown in Table 2.

It is noted in Table 2 that two questions (i.e. those focusing on the Policy and Stakeholder support pillars)

Table 2. Questions developed to evaluate feasibility of alternative management options

Pillar	Associated question and scoring system
Information	Is the information needed to complete this project available?
	0 = None of the needed information is available.
	3 = Some of the information needed is available but more studies need to be conducted.
	5 = The information exists but needs to be compiled.
	7 = The information exists and is partially compiled.
	10 = The information exists and is compiled.
Funding	Are there known funding sources that can support this project?
	0 = No funding opportunities exist for this project.
	3 = Funding opportunities exist that could fund a portion of the project.
	5 = Funding opportunities exist that could support the full project.
	7 = The project is partially funded and funding opportunities exist to fund the rest.
	10 = The project is fully funded.
Policies	Do current policies (regulations, ordinances) support this project?
	0 = Current policies are against this project.
	5 = There are no policies that support or inhibit this project.
	10 = There are policies in place that permit or encourage this project.
Institutions	Is there an institution that will take on and complete this project?
	0 = No institutions exist who can complete this project.
	3 = Potential institutions may exist.
	5 = Potential institutions exist but their institutional capacity is unknown.
	7 = Institutions exist and have the capacity to complete the project.
	10 = An institution or institutions can and have said they will complete the project.
Stakeholder Support	Is there sufficient stakeholder support for this project?
	0 = No stakeholders are generally against or totally unaware of this project.
	5 = Some stakeholders are in support and some are against this project.
	10 = Stakeholders are generally in support of the project.
Technology (timeframe)	In what timeframe is the project likely to be completed?
	0 = 20+ years
	3 = 10 years
	5 = 5 years
	7 = 3 years
	10 ≤ 1 year

were only given three scoring options and three defined responses. This was done because of the extensive discussion anticipated for these topics and the need to conserve time in the next meeting (Methodology Step 5) which spurred the decision that a rating of 3 or 7 would only be allowed for both categories, if a consensus on a 0, 5 or, 10 scoring could not be reached by the CAAC.

Step 5: Workshop aimed at obtaining consensus-based rating of the management alternatives 'feasibility components'

This working-lunch, mediated workshop was conducted on 15 February 2012 for the specific purpose of evaluating the management alternatives resulting from the 11 January 2012 brainstorming session (Methodology Step 2). In preparing for this workshop, each participant was informed of the workshop goals. Additionally, CAAC members that were previously inactive in the CARP process were sent personalized invitations to explain the need for their participation. This was done to ensure all bodies of knowledge, and opinions were included in determining the 'feasibility ratings' of the management alternatives. As three individuals were nevertheless unable to participate, the process was explained to them individually and their input obtained via individual interviews.

The structure of the workshop, developed in collaboration with ICPRB, was detailed in a way to ensure efficient use of time, as follows:

1. Upon registering, it was explained that the role of workshop participants was to represent their respective stakeholder groups, as a means of minimizing stakeholder personal opinions, and prevent biasing the overall results.

2. After registration, each management suggestion, previously developed by, and explained to, the CAAC (see Methodology Steps 2 and 3), was examined for the specific purpose of selecting those that were completely feasible or unfeasible/unnecessary, therefore meriting a 'yes' rating or 'no' rating, respectively. To facilitate this exercise, the management suggestions were grouped into sections based on the programmes objectives (storm water management alternatives; water supply increase alternatives). After reading each section, the CAAC was asked to state if any management alternatives merited a definite 'yes' or 'no' designation. These alternatives were then exempted from further discussion at the workshop. Those receiving neither designation, however, were placed in a 'maybe' list, with particular management suggestions being flagged as 'important'.

3. After identifying all the 'maybe' management suggestions (a total of 30 alternatives), the group discussed each one individually, beginning with the ones flagged as 'important' in terms of the six aforementioned ILBM pillar-based questions (Table 1). The participants then reached a consensus on a rating for each of the six questions, for each 'maybe' management suggestion. This resulted in the group discussing and rating a total of 180 questions, which were recorded for further analysis in Step 6 of this methodology.

Step 6: Develop prioritized list of management alternatives based on feasibility results analyses

The ratings, obtained by consensus within Step 5 of this methodology, for each of the six 'feasibility questions' were then summed. This resulted in each alternative receiving a total score out of a maximum score of 60 (i.e. 6 questions with maximum score of 10). The management alternatives categorized as a 'yes' also received a score of 60, while those included in the 'no' category received a score of 0. The alternatives with the highest scores received the most priority, and the lowest ones received the least.

This prioritized list was subsequently used in conjunction with an ICPRB technical analysis, completed after this study, to determine which programmes to recommend for the CARP, and ultimately the Pennsylvania State Water Plan. The final list of recommendations was presented to the CAAC on 11 April 2012. The meeting concluded with a discussion and subsequent vote, ensuring the major concerns about the process were adequately noted (see Results section) and that the CAAC was satisfied with the resulting recommendations.

An overall summary of the perceived importance of each governance pillar also was completed through an analysis of mean scores. A frequency diagram for each pillar also was developed to determine what ILBM governance pillars seemed to be stronger or weaker (i.e. more or less feasible) for the Rock and Marsh Creek watersheds.

RESULTS

The frequency with which each ILBM governance pillar received specific scores in the ranking exercise is represented graphically in Fig. 3, while the prioritized list of management alternatives (highest priority at the top) is presented in Table 3. The Table includes a brief description of each management alternative, as well as its total score. It also provides the scores for each individual governance pillar evaluated (i.e. the scores developed for the alternatives which received a 'maybe' designation). As previously noted, the programmes with scores of 60 are those which received a 'yes' designation in Step 5 of this study methodology. Similarly, those with scores of 0 are those which received a 'no' designation.

Table 3 also indicates the issues each alternative was seeking to address (i.e. availability, communication, data collection; policy/management; water quality; or storm water management) as well as their respective management approach (i.e. reduce demand, increase supply or increase protection). The issue and management approach for each alternative will be used to further evaluate the scores each alternative received, as highlighted in the following Discussion section.

DISCUSSION

Individual scores

The programmes with the highest priority (i.e. those with a score >45; see Table 3) were consistently those that were either already being initiated, or which could be quickly initiated. The creation of greenways in riparian areas (Ref. No. 6), for example is a project that had already begun in other regions of Adams County, and which could be easily campaigned to continue in the CWPA region.

Scores between 30 and 45 were comprised of a combination of completely and partially initiated projects and programmes. Those already partially developed had specific factors hindering their completion (e.g. stakeholder support; information). The interbasin water transfer

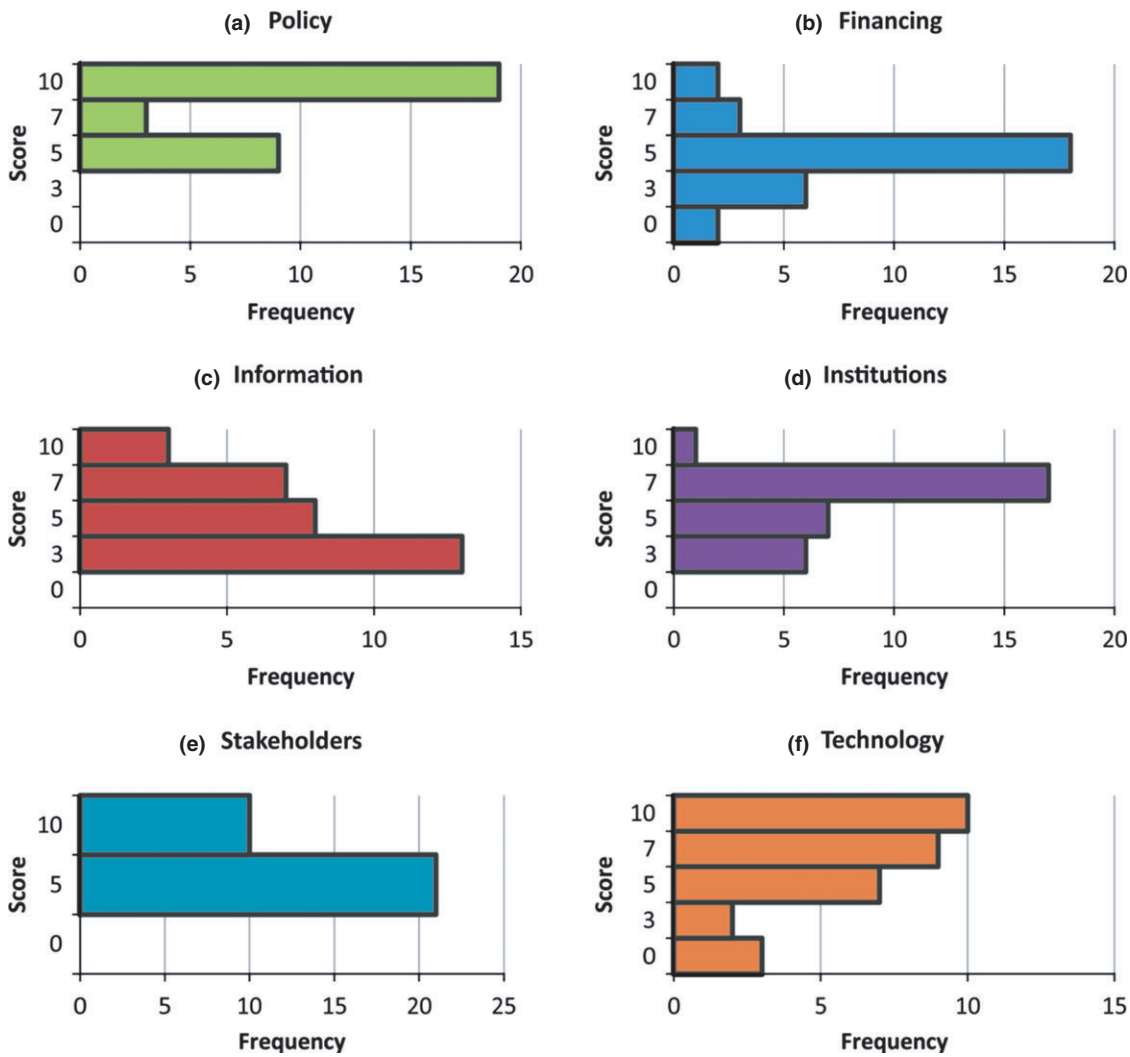

Fig. 3. Frequency diagrams of overall means scores for each ILBM governance pillar. (Mean values: (A) = 8.26; (B) = 4.81; (C) = 5.10; (D) = 5.87; (E) = 6.61; (F) = 6.58).

between the Susquehanna basin and the CWPA (Ref No. 21), for example had already been proposed, and was in the process of being permitted, although it received a score only in the mid-range (40) because of low stakeholder support (5) and information (3) scores.

The programmes receiving a score of 30 and below comprised one of three types of alternatives (i) those too technologically advanced to be completed on a voluntary basis (Ref No. 34, 36, 38, 39, 42 and 43); (ii) those requiring creation of an entirely new institution or implementing agency (Ref No. 41 and 44); or (iii) those with little stakeholder support (Ref No. 37 and 40).

There also were patterns associated with the issues each alternative was meant to address (i.e. storm water management alternatives; alternatives for increasing water supply). All those meant to increase water availability (a total of 12 programmes), for example had scores of 35 or less, with the exceptions of Ref. No. 21 (interbasin transfer) and 22 (creation of agricultural ponds), both receiving scores of 40. These relatively low scores, however, seem to indicate that increasing water availability in this watershed is neither feasible, nor desirable. This is consistent with the observation that the committee was evaluating each management suggestion with the understanding they were to be voluntary, thereby making projects seeking to increase water availability, which often use technological fixes, to be viewed as not being feasible.

This logic is reflected in the scores received by all the communication projects, which received scores of 43 or above (Ref. No. 2, 16 and 18 receiving 60, 46 and 43,

Table 3. Prioritized list of management alternatives, based on total scores determined during 15 February 2012 workshop

No.	Management alternative	Type A †	Type B‡	Pillar scores§ P	F	Inf	Ins	S	T	Total score
1	Community water supply systems to perform annual water audit to control water losses.	N-A	N-A	–	–	–	–	–	–	60
2	Enhance education with outreach and field trips for school age kids, municipal and elected officials; and storm water education to organizations and general public.	N-A	N-A	–	–	–	–	–	–	60
3	Public water suppliers to prepare and obtain DEP approval for Source Water Protection Plan.	N-A	N-A	–	–	–	–	–	–	60
4	Mason Dixon Utilities funded USGS (or similar) stream gage on Marsh Creek.	N-A	N-A	–	–	–	–	–	–	60
5	Adopt and enforce ordinances recommended by Adams County government.	N-A	N-A	–	–	–	–	–	–	60
6	Development and maintenance of riparian buffers along designated greenways (including Rock and Marsh Creek greenways), as specified in County Greenway Plan.	N-A	N-A	–	–	–	–	–	–	60
7	Develop local Association to facilitate coordination of volunteers to implement projects.	N-A	N-A	–	–	–	–	–	–	60
8	Implement local drought preparedness activities, including a drought advisory group.	N-A	N-A	–	–	–	–	–	–	60
9	Quantify maximum contaminant loads for pollutants of concern in impaired waterways by developing Total Maximum Daily Loads (TMDLs) for impaired reaches.	N-A	N-A	–	–	–	–	–	–	60
10	Implementation of storm water management programmes (not including creation of a Low Impact Development showcase site; see item 17 below).	N-A	N-A	–	–	–	–	–	–	60
11	Monitoring of ILBM governance pillars and physical environment to determine effectiveness of implemented management recommendations, particularly installed systems/practices; monitoring results should be utilized to adapt measure(s) to improve effectiveness.	DC	P	10	5	10	7	10	10	53
12	Installation of additional stream/staff gages and continued maintenance of existing gages.	DC	P	10	5	10	7	10	10	52
13	Water suppliers to participate in Potomac Drinking Water Source Protection Partnership.	Q	P	10	5	10	7	10	10	52
14	Adams County to provide funding for land preservation (purchasing conservation easements).	P/M	P	10	7	7	10	5	10	49
15	Develop list of projects requiring additional funding for future grant-seeking efforts;	P/M	All	5	10	5	7	10	10	47
16	Develop Strategic Communication Plan for general public and targeted stakeholders.	C	P	5	7	7	7	10	10	46
17	Establish collaboration with a developer in the CWPA to create a Low Impact Development (LID) showcase site to encourage environmentally sensitive development.	SW	S/D	10	5	7	5	10	7	44
18	Encourage communication between large water users on conservation measures being used within the community to foster idea sharing and long-term sustainability.	C	D	10	5	5	3	10	10	43
19	Establish groundwater protection ordinances for yield analysis (for large wells) to meet need for common methodology for municipalities to determine sustainable groundwater yields.	P/M	P	10	5	7	7	5	7	41

Table 3. (Continued)

No.	Management alternative	Type A †	Type B‡	Pillar scores§ P	F	Inf	Ins	S	T	Total score
20	Encourage adoption of wellhead protection ordinance to protect water sources.	P/M	P	10	5	7	7	5	7	41
21	Importation of water from Susquehanna Basin into GMA system through York Water.	A	S	10	10	3	7	5	5	40
22	Creation of additional agricultural ponds; surface water ponds for agricultural irrigation should be recommended practice for use of wells.	A	S	5	7	3	5	10	10	40
23	Establish water conservation programme responsive to water supply/demand conditions, especially for businesses and institutions affected by tourist influx (about 2 million) during summer.	P/M	D	5	5	3	7	10	10	40
24	Prepare Joint Comprehensive Plan, including sound land use policies and strong water supply and protection component; follow up with compatible zoning.	P/M	P	10	5	7	7	5	5	39
25	Develop municipal requirements for electronic submission of land development plans, inclusive of delineated wetlands that could be included in a GIS wetlands layer.	DC	P	5	5	5	7	5	10	37
26	Develop incentives or credits for implementing best management practices.	P/M	All	5	5	5	5	10	7	37
27	Develop list of favourable areas for development, and areas that are less sensitive; establish outreach team to demonstrate existing tools for choosing ideal development areas.	P/M	P	10	5	5	5	5	7	37
28	Implement more water efficient irrigation practices.	A	D	10	5	5	5	5	5	35
29	New developments should include/incentivize water conservation equipment.	A	D	7	3	5	7	5	7	34
30	Percolate water back into ground from sewage treatment plants.	A	S	10	3	3	7	5	5	33
31	New development requirements to provide additional storage capacity.	A	S	7	5	3	5	5	7	32
32	Seek, promote and implement wastewater treatment system reuse.	A	D	10	3	3	5	5	5	31
33	Create Marsh/Rock Creeks Water Management Council; to be composed of representatives from participating municipalities, municipal authorities and county government.	P/M	P	10	3	5	3	5	5	31
34	Investigate use of quarries as water storage facilities.	A	S	10	5	3	7	5	0	30
35	Implement storm water and grey water reuse programme(s).	SW	D	5	5	3	7	5	5	30
36	Enhanced or additional treatment mechanisms should be developed to provide additional water sources by further treating available surface and groundwater sources.	A	S	10	5	3	3	5	3	29
37	Encourage/increase water use registrations and/or metering to more accurately understand water uses in the watersheds for future water resources decision-making.	DC	19	7	3	3	3	5	7	28
38	Alternative means of conveyance from augmentation well to public water supply intakes to reduce consumptive loss	A	S	5	3	3	7	5	3	26
39	Create new, or rehabilitate an old reservoir, in/near the CWPA.	A	S	10	0	3	3	5	0	21
40	Establish standardized bypass for surface and groundwater withdrawals to ensure withdrawals do not dewater streams.	A	S	5	0	3	3	5	0	16
41	Implement sewage management districts where on-site septic systems are not managed by municipalities.	N-A	N-A	–	–	–	–	–	–	0
42	Install filter or catchment near Stevens Run outlet to prevent debris from entering Rock Creek.	N-A	N-A	–	–	–	–	–	–	0

Table 3. (Continued)

No.	Management alternative	Type A †	Type B‡	Pillar scores§ P	F	Inf	Ins	S	T	Total score
43	Separate downspouts from storm drains by routing run-off to a pervious surface (lawn, rain garden).	N-A	N-A	–	–	–	–	–	–	0
44	Establish storm water utility in the CWPA.	N-A	N-A	–	–	–	–	–	–	0

†Type A (type of programme): A = Availability; C = Communication; DC = Data Collection; P/M = Policy/Management; Q = Quality; SW = Storm water. N-A = Not Assessed.

‡Type B (management approach): D = Reduce Demand; S = Increase Supply; and P = Protection. N-A = Not Assessed.

§Pillar Scores: P = Policy; F = Finances, Inf = Information; Ins = Institutions; S = Stakeholder Support; T = Timeframe.

respectively). As these types of management projects required no technological advances, and could be achieved with minimal funding, they generally were favoured with this scoring system, suggesting this methodology was valuable in identifying the most feasible management suggestions within the context of a voluntary implementation setting.

Overall analysis

From an overall perspective (see Fig. 3), it is clear the Policy pillar tended to be strong, with an average score of 8.25 and exhibiting a very high occurrence of 10′s (i.e. 'current policies support the completion of this project'). This observation is consistent with the fact that the state of Pennsylvania has been relatively proactive in regard to water policy (e.g. Act 220).

In contrast, the Finance pillar had an average score of 4.81, with 5 (i.e. 'funding opportunities exist to fund the full project, but have not been acquired') being the most common score. This observation indicates that although policies exist to help implement projects, the funding does not necessarily follow. As funding opportunities do exist for many of these projects, however, it seems fair to assume many of the management alternatives could be implemented if someone actively spearheaded them.

The Information pillar had a mean score of 5.10, with the highest occurrence of scores in the 3–5 range (i.e. 'more studies need to be done' and 'the information may exist, but still needs to be compiled', respectively). This was expected due to the fact that inadequate information was indicated to be an issue for the Rock and Marsh Creek watershed in previously completed ICPRB studies. This could also explain why the two management suggestions referring to data collection (Ref. No. 4 and 12) received high stakeholder support scores (10) and high overall scores (60 and 52, respectively).

The mean score for the Institution pillar was 5.87, with 7 being the most common score (i.e. 'the institutions exist and have the capacity to take on the projects but have not yet committed or expressed interest'). This indicates a strong, although not completely sufficient, Institution pillar. This rating may change, however, when the management suggestions are published in the Pennsylvania State Water Plan, thereby making many alternatives more feasible. This scoring frequency also may relate to the Finance pillar. That is, if financing was to become available to the institutions, they would be more likely to take responsibility for a project.

Stakeholder support had a mean score of 6.61, with a highest occurrence of 5 (i.e. 'some stakeholders were for the project and some were against the project'). This is a common answer, as stakeholder groups often may not agree. These results may indicate a flawed question design in reducing the scoring options from five to three. Accordingly, future studies should exhibit more of a score gradient (i.e. 3 = approximately 25% of stakeholders are in support of this project; 5 = approximately 50%). This approach would likely provide more meaningful numbers in the rating process, as well as providing more informed management suggestions.

The remaining pillar, Technology, which was worded in terms of timeframe, had a mean score of 6.58, with high occurrences of 7 and 10, (i.e. 'one' to 'three year' projects). This indicates the CAAC was reluctant to propose long-term projects and, therefore, was likely (perhaps unconsciously) already thinking of the feasibility of alternatives when proposing them in the initial brainstorming meeting. Furthermore, all projects receiving a 0 or 3 score in technology (i.e. 'ten year' or 'twenty year' projects) also received a score of <30, indicating this pillar was particularly helpful in determining feasibility. This finding was not unexpected, however, noting that long-term projects are often expensive, exhibit high commu-

nity opposition and require extensive studies (also affecting the Finance, Stakeholder support and Information pillars).

Successes and challenges

As noted in Step 6 of the methodology, the CAAC discussed the study at its completion to determine the successes and challenges experienced in its conduct.

Based on the workshop experiences, the present study exhibited several successes, including:

1. Communication of the applicability and efficacy of the ILBM framework to the Rock and Marsh Creek watershed stakeholders.
2. Prioritization of all Rock and Marsh Creek watershed management suggestions.
3. Creation of a systematic methodology for discussing management projects in a timely and efficient manner.
4. Efficient and organized mediation of discussions between stakeholder groups within the CAAC.

There also remain some challenges, however, which can ideally be anticipated and dealt with prior to workshop implementation in future studies. These various challenges and issues, which were developed throughout the process and via discussions with the CAAC, are as follows:

1. Time management constraints

The design of the 15 February 2012 workshop required the CAAC to do the preliminary filtering of 'yes' and 'no' programmes, as well as answering the same questions regarding 30 different management programmes (the 'maybes'), all in 1 day. With 180 questions needing to be answered, this limited discussion to <2 min per question. This became tedious and somewhat frustrating to the committee by the end of the workshop. While the stakeholders recognized the need to proceed quickly, as well as the need to answer the questions, some participants wanted more time to discuss each option more thoroughly.

To better address stakeholder needs, it is recommended workshop be undertaken in several separate meetings for future studies. The first could focus, for example on filtering the 'yes' and 'no' alternatives, while the second could be devoted to the discussion of each management suggestion. While some time constraints are important to ensure the full attention of everyone in the group, an increased time interval of three or four minutes per management suggestion, and a maximum time of two-and-a-half hours per discussion, would prevent workshop participant 'burnout' and potentially produce more accurate results.

2. Question development

The wording of the questions must be carefully evaluated and completed. Leading or confusing language can frustrate stakeholders and also produce inaccurate results. The meaning of the ILBM pillar scores, for example required clarification several times during the workshop. A means of mitigating this problem would be to discuss the questions and scoring with the stakeholder group before asking them to answer, perhaps in a separate meeting, thereby ensuring all participants understand the wording and find the questions useful. In retrospect, although the questions in this study were developed in collaboration with ICPRB, having them reviewed by the CAAC prior to the workshop would have been optimal.

3. Necessary components to consider in addition to feasibility

While the present study focused on assessing the feasibility of alternative watershed management options, the CAAC concluded it would have been useful to include other components, including:

- A rating of the desire on the part of committee members/stakeholders to use the project results – The present study assumed a suggested management alternative would be something the committee wished to include in the recommendations, or that the 'Stakeholder' support pillar would take 'desire' into account. However, this was not necessarily the case. This suggests it may be a good idea to include a rating for this topic in future efforts.
- An evaluation of the sustainability of management suggestions – It was noted in this workshop that feasibility should not be the only factor considered in prioritizing basin management alternatives. If feasibility was the only factor used for eradicating insect infestations, for example many persistent pesticides would seem to be ideal solutions, as opposed to properly planting sustainable crops for the region. While this issue was beyond the scope of the present study, it is nevertheless important to consider some means of screening unsustainable programmes in future studies when assessing management alternatives. One possibility is the use of a sustainability rating system that excludes any programme not meeting a specific boundary or cut-off point.

4. Ensuring all stakeholders are represented

For this process to be accurate and unbiased, all stakeholders must be represented during the workshop. While this workshop comprised a fairly complete array of stakeholder representation, a few key players were absent because of scheduling conflicts or inadequate

interest, including the economic development board, some university communities and several local industries. While some scheduling conflicts are inevitable, attempting to accommodate all the stakeholders, as well as keeping them informed regarding the relevance of the process, is very important. Means of addressing this problem would be to schedule meetings very early, and to make personal visits to key stakeholders to explain the need and value of their participation.

5. Preventing a few individuals from dominating the discussions

Although sometimes unavoidable, the reality is that some people are more forceful in expressing their thoughts and opinions than others. Nevertheless, is important that all stakeholder groups are able to voice their opinions, even with time constraints. Although consensus was reached on all the questions considered in this workshop, a select set of participants consistently voiced their opinions, thereby unduly dominating the discussions. A means of mitigating this problem could be to seat participants in the meeting room within representative groups (agriculture; industry; policymakers), and subsequently ask each group for input on each question, thereby helping ensure that each group is consulted on each question.

Many of these challenges are inevitable when working with a large stakeholder group. Nevertheless, the ILBM-based methodology used in the present study proved very useful in helping the CAAC reach consensus on the feasibility of the suggested management alternatives. The hope is that this methodology, when properly applied, will help future watershed managers and consultants navigate the use of stakeholder-based watershed management.

CONCLUSIONS

Surface water sources, whether they are lakes or rivers, must be managed in a comprehensive, integrated manner to ensure their sustainable use. To this end, based on its use in the present study and elsewhere, the ILBM process represents a useful platform for water managers and other stakeholders to develop effective and sustainable management plans. The method of consensus-based analysis used in the present study previously proved effective for the Lerma River–Lake Chapala basins in Mexico, as well as being very useful for the Marsh and Rock Creek sub-basins. Implementation and assessment of the ILBM platform in the present study, and in other locations around the world, has demonstrated its considerable value in helping water managers and stakeholders gather information, identify governance issues, prioritize management projects and establish cooperation among those involved in effective management of lake and rivers basins.

The present study provided a useful case study for guiding those involved in stakeholder workshops and future basin management efforts, whether for lake or river basins. It also contributed to the growing experiences and 'lessons learned' being developed around the world in the application and evaluation of the ILBM framework and collaborative management approach to different types of freshwater systems, as well as contributing to effective management of the Marsh and Rock Creek watersheds of the Potomac River Basin.

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