A FUNCTIONAL APPROACH TO WATER QUALITY CLASSIFICATION

by

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ABSTRACT

A FUNCTIONAL APPROACH TO WATER QUALITY CLASSIFICATION

Joseph John Pastic

Submitted to the Department of City and Regional Planning on August 1, 1968 in partial fulfillment of the requirement for the degree of Master of City Planning.

On both national and state levels the basis for water quality improvement programs is the application of minimum required levels of treatment for pollution sources. This policy leads to confusion over the objectives of water quality improvement and inefficient allocation of available resources. The basic objective of these programs should be the enhancement of beneficial water uses.

A decision as to the classification of a water area cannot be effectively made without considering all of the parameters bearing on the extent of activities possible. Although water quality is an important determinant, equally important are parameters of physical size, form in which the area occurs, adequate access, and societal needs for a particular use. The uses which should be enhanced are those of recreation and conservation, for they are particularly sensitive to the above parameters. The interdependence of the parameters is illustrated through an examination of the Charles River basin. This case study reveals that the recreation and conservation uses possible are quite limited in some sections regardless of water quality, but become greatly expanded if land facilities, access and space parameters are manipulated with water quality. The present course is one of overemphasis on water quality improvement and must be altered so as to place water quality in a realistic perspective.

Thesis Supervisor: John T. Howard
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INTRODUCTION

PURPOSE OF STUDY

The purpose of this study is to compare the several parameters determining the types and magnitudes of recreation and conservation uses possible at a water area, in order to place in perspective the importance of water quality parameters. Such a study is worthwhile at this time because of the great attention being given to the control of water quality at both the Federal level (Water Quality Act of 1965, Clean Water Restoration Act of 1966) and the state level (e.g., Massachusetts General Laws Chapter 685, § 26-50, "An Act Establishing a Water Pollution Control Division in the Department of Natural Resources"). It is clear that the principles guiding the classification of waters are the imposition of uniform treatment levels (see pp.10-12) and, to a lesser degree, interest group pressure (see pp.12,83-84), rather than the enhancement of those uses beneficial to the public.

The enhancement of beneficial uses is, however, an explicit objective of Federal (see pp.7-8) and generally of state (p.11) programs. But this objective cannot be rationally met if the uses possible are not considered in the first place, rather than--as it now stands--

resulting from the imposition of uniform treatment levels. And, in order to fully understand the limits and possibilities of a water area as to beneficial uses, one must be cognizant of the quality, quantity, access, and topographic parameters; not those of water quality alone. Further, one must have a frame of reference from which to establish needs that must be supplied by the water areas. It is to this problem that the thesis is directed.

RESEARCH DESIGN

A search of the literature showed that much had been written regarding the water quality parameters necessary for various recreation and conservation uses. Among the most notable is Water Quality Criteria,[1] which besides describing California's water quality parameters also summarizes 3827 pieces of literature including a summary of state roles and quality criteria for the major beneficial uses of water.

The Interim Report of the National Technical Advisory Committee on Water Quality Criteria[2] includes five sections dealing with Water Quality Criteria for: Recreation

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[1] Jack Edward McKee, Water Quality Criteria, Sacramento: State Water Quality Control Board, 1963, pp. 28-64, 88-123.

[2] Federal Water Pollution Control Administration, Interim Report of the National Technical Advisory Committee on Water Quality Criteria to the Secretary of the Interior, Washington, D.C., June 30, 1967.

and Aesthetics; Fish, Other Aquatic Life and Wildlife; Public Water Supplies; Agricultural Uses; and Industrial Water Supplies.

The data on space, access, and related land characteristics was taken from Outdoor Recreation Space Standards.[3] This publication is a summary of 135 private and governmental publications, plans, and reports.

In all of the references, however, that which was lacking is an effort to bring these parameters together so that their total influence on recreation and conservation uses can be determined. ORRRC Study Report No. 10 established the concept of the "duty of water for recreation facilities":

> ". . . the duty of water for recreational purposes will . . . be applied to those characteristics of water which will properly describe its amount, extent, distribution and characteristics needed for practical production of recreational opportunity.
>
> "The duty of water for recreational purposes has more than one aspect. For certain kinds of uses (i.e., sailboating), the principal requirement is one of distribution in space of the water resource; for another type of use it may be distribution in time which is most important (e.g., white water canoeing). In still a third type of use (e.g., swimming), the

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[3] U.S. Department of the Interior, Bureau of Outdoor Recreation, Outdoor Recreation Space Standards, Washington, U.S. Government Printing Office, 1967.

> principal requirement may be one of water quality.
>
> ". . .
>
> "Only by recognition of these differences in the requirements for various uses is it possible even to discuss the question of water requirements for recreational purposes.
>
> ". . .
>
> "The data available for [some] kinds of recreational uses are generally inferential--they do not deal with the duty of water itself. If the duty of water for these uses is estimated at all, the estimates of the resource requirement to support the recreational activity are based on the quantity or intensity of application of the accoutrements of the recreational process. The best example is the water required for boating. The duty of water for boating has but little relation to the volume of water. Sailboating, for example, can be enjoyed quite as much on a lake that averages 10 feet deep as on one that averages several hundred feet deep. The volume of water involved bears but little relation to the requirement for the recreational use."[4]

This served as a point of departure for the study. The full impact that controlling all of these parameters together, rather than only those of water quality, can have on the decision process of setting water classifications may not be realized without applying the principles to a case study. That chosen was the Charles

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[4] Outdoor Recreation Resources Review Commission, Water for Recreation--Values and Opportunities, Study Report 10, Washington, U.S. Government Printing Office, 1962, pp. 11-12.

River basin, because this basin has a long history of providing recreation activities and has captured the attention of several active interest groups--private and governmental. A more complete description of the techniques used in the case study is found on pp.78-83.

THE SETTING

Recently the Commonwealth of Massachusetts, with the support and prodding of the Federal government, has undertaken a program of water-pollution abatement. The central element vital to the program is the concept of classification of waters, whereby the uses to which water may be put are made explicit.

The system of classification in Massachusetts is based on seven (7) categories of water quality. Four of these categories are applicable to fresh water (A, B, C, D), and three categories are applicable to salt and estuarine waters (SA, SB, SC). Each category is comprised of twelve (12) specific characteristics:

(1) dissolved oxygen
(2) sludge deposits--solid refuse--floating solids--oils--grease--scum
(3) color and turbidity
(4) coliform bacteria per 100ml.
(5) taste and odor
(6) pH
(7) allowable temperature increase
(8) chemical constituents
(9) radioactivity
(10) total phosphate
(11) ammonia
(12) phenols

Each category of water quality is defined through minimum levels, maximum levels, and/or ranges of each characteristic and use. From highest to lowest quality they are: A, B, C, D. Alternatively, for marine and estuarine waters they are: SA, SB, SC. Taking the Massachusetts standards as an example, Class "A" is suitable for all uses (but is reserved for water supply); Class "B" is suitable for all uses, including water supply if treated, notably water-contact activities; Class "C" is not suitable for water-contact activities; and so forth. A full description of these quality levels is in Appendix I.

It is intuitively clear that the activities possible at a given quality level presuppose the adequacy of other characteristics--e.g., sufficient surface area, depth, and shore characteristics. These characteristics should be taken into account meaningfully if best results are to be obtained. An area may have water of an extremely high quality but be virtually useless because of the unsatisfactory state of its other characteristics. Public access points are required for boating (and in some states rights of public access on the water surface must be obtained) and must be suitably equipped for optimal use. Swimming and shore fishing require significant areas for the activity to be carried on. A waterfowl

propagation area must have favorable marsh areas and relative seclusion. Since much of the public concern for water quality improvement should be based on the uses made possible; and, since the uses possible depend on more than water quality, it follows that the total set of characteristics must be considered in setting water classifications.

Since the Federal government has served as the catalytic agent, it is worthwhile to examine its attitude towards water quality classification. The Federal Water Pollution Control Act, as amended by the Water Quality Act of 1965, requires the states to classify their waters according to the uses expected from the water area.

> "In establishing such standards the Secretary of the Interior, the Hearing Board, or the appropriate authority shall take into consideration their use and value for public water supplies, fish and wildlife, recreational purposes, agricultural, industrial, and other legitimate uses."[5]

> "Economic, health, esthetic, and conservation values which contribute to the social and economic welfare of an area must be taken into account in determining the most appropriate use or uses of a stream. <u>There ought to be a constant effort to improve the quality of the water</u>

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[5] Federal Water Pollution Control Act; Public Law 84-660 as amended by the Federal Water Pollution Control Act Amendments of 1961 (PL 87-88), the Water Quality Act of 1965 (PL 89-234), and the Clean Water Restoration Act of 1966 (PL 89-753), § 10(c)(3).

supply, it being recognized that the improvement of the quality of water makes it available for more uses."[6] (Emphasis supplied)

"Water quality standards are not designed for use primarily as an enforcement device; they are intended to provide the Secretary [of Interior] and State and local agencies with additional tools for objective and clear public policy statements on the use or uses to which specific segments of interstate waters may be put."[7]

"The committee intends that water quality standards should be applied on the basis of the water quality requirements of present and future uses of a stream or section of stream, after due consideration of all factors and variables involved."[8] (Emphasis supplied)

"Water quality criteria should be applied to the stream or other receiving water or portions thereof. The criteria should identify the water uses to be protected and establish limits on pollutants or effects of pollution necessary to provide for such uses."[9]

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[6] Senate Report No. 10 on the Federal Water Pollution Control Amendments of 1965, 89th Congress, 1st Session.

[7] Ibid.

[8] Ibid.

[9] U.S. Department of Interior, Federal Water Pollution Control Administration, Guidelines for Establishing Water Quality Standards for Interstate Waters (Under the Water Quality Act of 1965, Public Law 89-234), Washington, U.S. Government Printing Office, May 1966, pp. 5-6.

An apparently recent pamphlet[10] used for public relations has succinctly outlined the process in the order it is supposed to occur, thus summarizing the legislative intent:

> "Water quality standards include three essentials:
>
> > "1. WATER USES. As required by the law, the states held public hearings to determine water uses desired for and appropriate to each stretch of their interstate and coastal waters. Hearing witnesses --including private citizens, conservation spokesmen, and representatives of industry, agriculture, local government, and others -- helped decide uses for which particular water stretches would be reserved. In most cases, several desired uses--such as drinking water, swimming, fishing, boating, agriculture, industry, navigation--applied to the same stretch of water. In such cases, standards were set to permit the highest use, thus requiring other users to bring their waste treatment up to this standard. After the hearings, state pollution control officials made final decisions assuring the uses each stretch of water must support . . . now and in the future.
>
> > "2. CRITERIA. Once uses were chosen, state authorities, in consultation with scientists, engineers, and other water experts, decided what substances and how much of each the

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[10] Izaak Walton League's "Citizen Workshops for Clean Water for America" Project, CLEAN WATER, It's Up To You, Glenview, Illinois, undated, pp. 15-16.

> waterway could absorb--and still be fit for the desired uses. These limits (in the Act called 'criteria') are expressed in terms of ranges or critical levels of substances (such as dissolved oxygen, total dissolved solids, sediment, heat, bacteria, toxic elements, etc.) legally allowed in the water. To be acceptable, the criteria had to be adopted by the state agency as a state rule or regulation having the force of law.
>
> "3. IMPLEMENTATION PLAN. . . ." (Emphasis supplied)

The first point to establish is the importance of defining the uses to which the waters are to be put. It is not the aim of the Federal government only to create new enforcement worries for the states--but to release this resource from old shackles of pollution so that it may better serve society.

The legislative intent also given as enhancement of all water resources has, <u>in general</u>, shifted the emphasis from a consideration of uses that are desired to that of imposing a uniform level of treatment on all polluters.

> "No standard will be approved which allows any wastes amenable to treatment or control to be discharged into any interstate water without treatment or control regardless of the water quality criteria and water use or uses adopted. Further, no standard will be approved which does not require all wastes, prior to discharge into any interstate water, to receive the best practicable treatment or control unless it can be demonstrated that a lesser

> degree of treatment or control will provide for water quality enhancement commensurate with proposed present and future water uses."[11]

That the Federal government requires a minimum level of treatment for all pollution sources has led the states to do likewise. The general policy of the Massachusetts Pure Water Program includes the following:

> "All waste sources on fresh waters will be required to be treated to the secondary level regardless of the stream classification assigned. Secondary treatment will generally refer to biological treatment as applicable and/or its industrial wastes treatment equivalent all as determined by the Division of Water Pollution Control. Secondary treatment efficiencies shall range from 80 to 95% BOD removal with correspondingly similar removals on other waste parameters. On coastal and marine waters the degree of treatment required will be that which will attain the particular classification set on the area waters."[12]

The process resulting from the policy of requiring uniform treatment is the following:

Tentative classifications for a given body of water are developed by the State Water Resources Commission (solely) on the basis of engineering and hydraulic con-

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[11] U.S. Department of Interior, Federal Water Pollution Control Administration, Guidelines for Establishing Water Quality Standards for Interstate Waters (Under the Water Quality Act of 1965, Public Law 89-234), Washington, U.S. Government Printing Office, May, 1966, p. 7.

[12] Mass. Water Resources Commission, Water Quality Standards, Vol. 1: Laws, Policy & Standards, June 1967.

ditions. Existing pollution sources are assumed to be given a minimum level of treatment; these loads are then compared with hydraulic data (e.g., flow in a stream) for an estimate of future water quality. These hypothesized qualities are then reviewed by the Water Resources Commission and the Division of Fisheries and Game for uses that will be possible. This tentative set of classifications is then presented at a public hearing. Feedback from concerned parties is noted as a basis for final modifications. The classifications are then submitted to the Secretary of the Interior.

Because of this emphasis on treatment rather than planned uses, resources are expended with only indirect reference to expected benefits. That is, the possibility of new or expanded usage is secondary to the concepts of equity through nearly-uniform treatment.

Furthermore, the sole reliance on water quality criteria can be misleading in determining the uses which can be realized. Since the most recent Federal legislation (1966), there has been an indication on the part of the Federal Water Pollution Control Administration of the importance of not only water quality, but other use characteristics.

> "The Committee emphasizes that the management of water resources to enhance recreational opportunities requires more

> than the maintenance of water quality. In addition to quantity, location, and accessibility of water, management for recreation may involve seasonal and even daily water level regulation during seasons and hours of peak use."[13] (Emphasis supplied)

Besides requiring specific water quality, water quantity, and related characteristics, recreation activities may themselves affect the water and adjacent land. These changes may impair or completely preclude other activities, and set limits on the magnitude of the activities which can occur. From a planner's point of view, it is valuable to understand how and to what extent these characteristics interact. Where specific quantification is not possible, it is nevertheless important for the parameters to be indicated qualitatively.

Recreation and conservation activities have been isolated from other water uses because of their unique nature. They are public goods; and since there is relatively little control over who would use the facilities in an area, they must be supplied primarily through the public sector.

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[13] Federal Water Pollution Control Administration, Interim Report of the National Technical Advisory Committee on Water Quality Criteria to the Secretary of the Interior, "Water Quality Criteria for Recreation and Aesthetics," (Gold), Washington, D.C., June 30, 1967, p. 22.

Unlike other water uses, recreation and conservation uses impart benefits which are difficult to place in monetary terms.[14] Moreover, they have been consistently given a low priority relative to other water uses. However, the general agreement as to the value of water for uses like industrial, agricultural, and municipal water supplies, together with the technological ability to create sources of water for these uses, assure no problems in these areas.[15] Regarding industrial concern with water quality, there is little evidence to indicate that the need in this area is for quality improvement.

> ". . . water treatment technology in its present state of development permits the utilization of surface water of literally any available quality to create waters of any desired quality at point of use. Such treatment may be costly, but this cost is usually a small part of the total production and marketing costs.
>
> ". . .
>
> "The quality characteristics of the water supply for an established industry

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[14] See for full development: Marion Clawson, The Economics of Outdoor Recreation, Baltimore, Johns Hopkins Press, 1966; Nathaniel Wollman, The Value of Water in Alternative Uses, Albuquerque, University of New Mexico Press, 1962.

[15] Ackerman and Lof, Technology in American Water Development, Baltimore, Johns Hopkins Press, 1959.

> at a given site, if allowed to deteriorate from the range usually experienced for those characteristics of significance to that industry, can cause an undesirable increase in the cost for treatment. Contrarywise, an improvement in the quality of the same supply will not significantly decrease the cost of treatment at an existing installation."[16] (Emphasis supplied)

Now, however, the picture is changing, the importance of water-based recreation activity cannot be overstated. The rapid increases in leisure time, along with rising living standards with which to enjoy this leisure, have increased per capita demands for facilities to enjoy it. Much of this demand is reflected in per capita increases in outdoor recreation activities.

On the national level, the growing importance of water-oriented recreation has been documented in the series of reports by the Outdoor Recreation Resources Review Commission, especially in its summary volume "Outdoor Recreation for America," and by supplemental studies by the Bureau of Outdoor Recreation.

> "Outdoor recreation is a preferred form of leisure activity for increasing millions of Americans; water and shorelines serve as a focal point for many

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[16] Federal Water Pollution Control Administration, Interim Report of the National Technical Advisory Committee on Water Quality Criteria to the Secretary of the Interior, (Bronze), Washington, D. C., (June 30, 1967, pp. 4, 5), "Water Quality Criteria for Industrial Water Supplies."

preferred forms of outdoor recreation. Quantity, location and accessibility as well as quality of water are prime factors in satisfying outdoor recreation demands. These facts are set forth in 'Outdoor Recreation for America,' the 1962 report of the Outdoor Recreation Resources Review Commission (ORRRC), and are confirmed by subsequent surveys of outdoor recreation activities and demands carried out by the Bureau of Outdoor Recreation (BOR), Department of the Interior.

"One of the major findings and pervasive themes of the ORRRC Report was that most people seeking outdoor recreation (90 percent of all Americans) seek it associated with water--to sit by, to walk alongside, to swim and to fish in, and to boat on.

"Based on a 1960 survey, ORRRC found--for example--that swimming was the No. 2 outdoor recreation activity and was likely to be the most popular by the turn of the century. Boating and fishing were among the top 10 activities. Walking, camping, picnicking, and hiking--also high on the user preference list--are more attractive, higher quality experiences near clean water.

"A 1965 survey by the Bureau of the Census, Department of Commerce, for BOR indicates that present and anticipated increases in all water-related activities far surpass the ORRRC projections.

"BOR's 1965 survey found--for example--that the popularity of swimming, now second only to 'walking for pleasure,' is increasing so fast that it is expected to be the No. 1 outdoor activity by 1980 and to continue to hold that place in 2000.

"Expressed in other terms, BOR found that outdoor swimming 'participation occasions' increased 44 percent between 1960

> and 1965 (while the population of individuals 12 years old and older increased 8 percent). Between 1965 and 1980, BOR expects that swimming will increase 72 percent (while population is expected to increase 29 percent), and between 1965 and 2000, 207 percent (while population is expected to increase 76 percent).
>
> "Expressed in terms of individuals, rather than 'occasions,' BOR's 1965 survey found that 49 percent of the population (12 years old and older) went swimming outdoors that year, an increase of 15 percent since 1960. Comparable figures for some other water-related activities:
>
> "Fishing--30 percent of population participated, an increase of 12 percent since 1960.
>
> "Boating (other than canoeing and sailing)--24 percent, an increase of 18 percent."[17] (Emphasis supplied)

Table 1 shows recreation occasions per person in the peak season for 1960, and projections for 1976 and 2000, and indicates the growing relative importance of water-based recreation. By isolating data for boating, fishing, swimming and water skiing, the trend becomes clearer. Total per person recreation occasions for these activities are: 8.66 for 1960; 10.96 for 1976; and 13.85 for 2000. For the other activities, the total per person recreation occasions are: 25.95 for 1960;

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[17] Federal Water Pollution Control Administration, Interim Report of the National Technical Advisory Committee on Water Quality Criteria to the Secretary of the Interior, "Water Quality Criteria for Recreation and Aesthetics," (Gold), Washington, D.C., June 30, 1967, pp. 19-21.

TABLE 1

RECREATION OCCASIONS PER PERSON IN THE PEAK SEASON FOR THE UNITED STATES, 1960, 1976 AND 2000

Activity	1960	1976	2000
Outdoor Concerts	.21	.27	.36
Outdoor Sports	1.32	1.45	1.61
Bicycle	1.75	1.71	1.75
Boating	1.22	1.64	2.16
Camping	.46	.65	.91
Driving	6.68	7.74	8.59
Fishing	1.99	2.02	2.02
Hiking	.26	.36	.48
Horse Riding	.42	.47	.55
Hunting	.73	.71	.67
Nat. Study	.75	.88	1.02
Picnicking	2.14	2.41	2.71
Competitive Sports	3.63	4.76	6.46
Sightseeing	2.20	2.63	3.20
Swimming	5.15	6.82	8.94
Walking	4.34	4.94	6.07
Water Skiing	.30	.48	.73
Ice Skating	.52	.75	1.03
Sled Riding	.44	.51	.67
Snow Skiing	.06	.10	.15
Mt. Climbing	.04	.05	.07
Population 12+	34.61	41.35	50.15

SOURCE: Edwards and Kelcey, Massachusetts Outdoor Recreation Plan 1966, Massachusetts Department of Natural Resources, 1966, p. 97.

NOTE: Mountain Climbing is assumed to increase at the same rate as Hiking and Snow Skiing at the same rate as Water Skiing

30.39 for 1976; and 35.27 for 2000. Although both sets of data are increasing, those for water-based recreation are increasing at a faster rate. The ratios of the former to the latter are: .334 for 1960; .360 for 1976; and .392 for 2000.

Likewise, at the state level, there is an accelerating need for accommodating ever more recreation activity, much of it water-oriented.

The Massachusetts Outdoor Recreation Plan, 1966,[18] is a study of the recreation needs of the people and recreation resources of the state. One of its important conclusions is the recognition of the importance of water.

> "Water is a focal point for recreation. Among the active pursuits, swimming is the most popular activity for persons on vacations, trips, and outings; fishing ranks second, followed by boating. For persons recreating near home the most popular pursuits are those which can be engaged in for a short period of time. Among the active pursuits competitive outdoor sports, swimming, and picnicking head the list."[19]

Notwithstanding the importance of water quality, the most urgent problems are those of adequate public access, acquisition of areas contiguous to the water, and interference among competing uses.

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[18] Edwards & Kelcey, Massachusetts Outdoor Recreation Plan 1966, Massachusetts Department of Natural Resources, 1966.

[19] Ibid.

In the case of rivers and streams, the effects of pollution have been noted:

> ". . . many miles of Massachusetts rivers and streams are polluted to the extent that they have no recreation value, little aesthetic value, limited industrial value and are used largely for the transportation of sewage and waste."[20]

But the importance of establishing adequate access --both physical and legal--is clearly brought out:

> ". . . the aggregate supply for water-oriented activities includes the Great Ponds, navigable streams, coastal waters and public reservoirs. Availability to the general public of these recreation resources is limited in part by the degree of public access provided. In only a few cases does a permanently guaranteed right-of-way prevail."[21]

In the case of rivers and streams:

> "The Massachusetts Division of Fisheries and Game estimates that 13,000 acres of water on some 6,700 miles of named streams in the Commonwealth are potentially fishable. These have outstanding potential for meeting recreation demands because they are distributed in every city and town throughout the Commonwealth. This potential is not being realized, however, because most of this water is inaccessible, or accessible only by boat or with great difficulty due to riparian ownership of the banks of streams."[22]

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[20] Ibid.

[21] Ibid.

[22] Ibid.

Great Ponds are those bodies of water which, in their natural state, are 20 acres or larger in size. By Massachusetts law, these bodies of water belong to the Commonwealth and the public has a right to use them for "fishing and fowling."[23] There is a provision for the Commonwealth to provide public access to them.

There are approximately 755 Great Ponds in Massachusetts providing 83,109 acres of water surface. Of these, 121 Ponds with 10,376 acres have public access, and an additional 378 Ponds with 49,977 acres have restricted access. The public access on the 121 Ponds has been permanently established on only 35 of them. Those Ponds with restricted access have restrictions such as shore fishing only, town residents only, or private launching facilities only. Only 251 of the 755 Great Ponds have had the Public access legally established by surveys of the Department of Public Works. A regional breakdown of these Ponds is shown in Table 2.

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[23]Massachusetts General Laws, Chapter 131.

TABLE 2

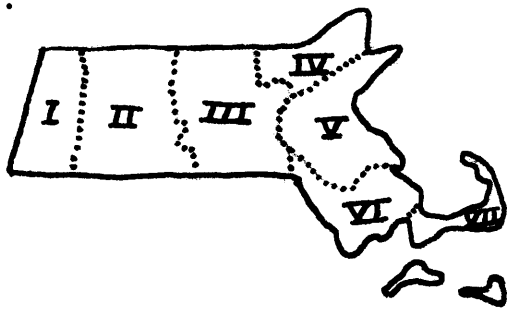
MASSACHUSETTS GREAT PONDS: Number and Acreage by Availability of Access and Region

Region	Total		With Public Access*		With Restricted Access**	
	Number	Acreage	Number	Acreage	Number	Acreage
I	86	7,747	14	185	37	4,625
II	97	7,695	17	874	44	3,321
III	110	18,221	12	1,147	45	12,445
IV	53	5,318	4	114	31	3,509
V	141	15,659	13	2,403	87	9,112
VI	185	20,836	12	395	118	15,482
VII	83	7,633	49	5,258	16	1,483
Massachusetts	755	83,109	121	10,376	378	49,977

*Only 35 of these are permanently established.

**Restrictions such as shore fishing only, town residents only, private launching facilities only.

SOURCE: Edwards & Kelcey, Massachusetts Outdoor Recreation Plan 1966, 1966, p. 35, Mass. Dept. of Natural Resources.



To indicate the potential contribution of just the Great Ponds towards recreation areas, refer to Table 3. By providing only public access and adequate auxilliary facilities at Great Ponds presently having no public access, almost all of the 1970 fishing demand and nearly 3/4 of the 2000 demand can be met. For boating, 1/4 of the 1970 demand and over 1/10 of the 2000 demand can be met. For water-skiing, 1/5 of the 1970 demand and nearly 1/10 of the 2000 demand can be met.

TABLE 3

UNUSED CAPACITY OF GREAT PONDS

	DEMAND — No. of People at one Time			SUPPLY — No. of People Accommodated at one Time, 1965	
	1960	1970	2000	areas presently open to the public	Great Ponds having no public access
Swimming	383,900	546,400	1,033,900	243,100	N/A*
Fishing[1]	147,600	165,900	220,600	63,209	164,000[1]
Boating[2]	90,900	128,700	241,900	8,778	31,400[2]
Waterskiing[3]	22,100	36,800	82,700	1,200	7,560[3]

N/A* not available

1 The ultimate capacity of all Great Ponds.

2 The ultimate capacity of Great Ponds over 50 acres in size

3 The ultimate capacity of all Great Ponds larger than 100 acres

SOURCE: Edwards & Kelcey, Massachusetts Outdoor Recreation Plan, 1966, Massachusetts Department of Natural Resources, 1966, pp. 102-103, p. 119.

Furthermore, there is a steady loss of lands suitable for recreation and conservation uses. These losses are caused primarily by development for urban uses, but can also be through other unfavorable topographic changes like marsh drainage, use as dumping areas, etc. From 1957 to 1965, almost as much land recommended for acquisition had to be dropped as had been acquired.[24] The totals and breakdown by region are shown in Table 4.

Together with absolute population increases, this burgeoning demand for recreation areas--much of which is water-oriented--has created and will continue to create a growing shortage of suitable areas.

Although the demand for water for all uses is increasing, recreation and conservation areas are, for all practical purposes, not yet capable of being supplied by technological simulation, nor are the prospects for such a breakthrough encouraging. Consequently society faces a fairly constant supply of suitable areas. That these areas involve both water quality and associated land and water characteristics makes it extremely important to simultaneously treat all of the parameters.

The activities selected for study represent a range of quality, quantity, and associated parameters. The activities included for study are:

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[24] Edwards & Kelcey, Massachusetts Outdoor Recreation Plan 1966, Massachusetts Department of Natural Resources, 1966.

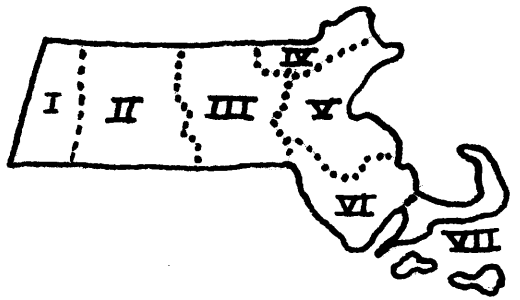
TABLE 4

MASSACHUSETTS COMPARISONS
OF POTENTIAL PUBLIC RECREATION ACREAGE,
1965 and 1957 by Region

	Region							
	I	II	III	IV	V	VI	VII	TOTAL
Acquisition Recommended in 1957	84,297	52,580	37,411	4,565	14,765	9,570	14,072	217,260
Acreage Dropped*	9,248		1,376	900	3,650	215		15,389
Acreage Acquired	7,005	5,230	2,368	15	857	894	36	16,405
Acquisition Recommended in 1965	4,034	7,220	3,873	790	115	100	14,201	30,333
Present Potential Acreage	72,078	54,570	37,540	4,440	10,373	8,561	28,237	215,799

*Due to change in use, availability or other reasons making it no longer desirable for public acquisition.

SOURCE: Edwards & Kelcey, Massachusetts Outdoor Recreation Plan 1966, Massachusetts Department of Natural Resources, 1966, p. 38



-- non-power boating
-- power boating
-- swimming
-- water skiing
-- fishing, and fish and wildlife propagation

and are among the uses considered by the Outdoor Recreation Resources Review Commission in its studies.

Boating activities are secondary-contact activities because they entail ancillary contact with water. Swimming and water skiing are primary-contact activities because there is direct contact with the water. Their common attribute is an integral need for water, and they represent a full range of activity and disturbance levels. Fish and wildlife propagation must be considered for two reasons. The level of fishing intensity possible depends on the ability of the water to support and continue fish species. Furthermore, other recreation activities related to wildlife involve water less directly but nevertheless integrally. Whether one is interested in passive nature study or more active hunting, trapping, or other activities, an ample wildlife supply is necessary.

The activities will be considered in their order of increasingly stringent water quality, with the exception of fishing and fish and wildlife propagation. Although these two activities may give an impression of having less stringent requirements, they cannot, in reality, be compared to man-oriented activities.

DETERMINANTS OF RECREATION AND CONSERVATION ACTIVITIES

WATER QUALITY CRITERIA

Water quality criteria are designed to control three factors:

> (a) the water "must be esthetically enjoyable, i.e. free from obnoxious floating or suspended substances, objectionable color, and foul odors;"
>
> (b) the water "must contain no substances that are toxic upon ingestion or irritating to the skin of human beings;" and
>
> (c) the water "must be reasonably free from pathogenic organisms."[1]

Which of these factors is to be regulated depends on the activities to be accommodated. Primary water contact activity (e.g., swimming and water skiing) requires control of all these factors; activities not entailing primary water contact are primarily concerned with the first of these factors--aesthetic considerations--the other factors not being as critical. For the propagation of fish and wildlife, the water is more than a casual part of the environment. At least in the case of wildlife, fish and plants requiring a water environment,

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[1] Jack Edward McKee, Water Quality Criteria, Sacramento, State Water Quality Control Board, 1963, p. 118.

more than threshhold levels should be considered.

Criteria established to regulate aesthetic characteristics have not advanced past the description stage. In many cases all that is established is that the limits for some pollutants is, for example: "None in such concentrations that would impair any usages specifically assigned to this class." This is understandable, since the aesthetic content of anything involves a subjective reaction.

Some pollutants both cause aesthetic damage and have toxic effects on man, depending on the relative amounts of the pollutants in the water. Ammonia and Phenols, for example, offend the aesthetic sense long before they reach toxic levels.

Where quantitative levels have been enunciated, the basis for the value is the concentration appearing as a threshhold to some statistical fraction of people.

Using the parameters considered by the Massachusetts Water Resources Commission, those characteristics dealing with aesthetic control are:

-- sludge deposits--solid refuse--floating solids--oils--grease--scum
-- color and turbidity
-- taste and odor
-- chemical constituents
-- ammonia
-- phenols
-- temperature can also be considered an aesthetic characteristic, especially where primary water contact activity is present

-- dissolved oxygen can also be considered an aesthetic characteristic, in that below a minimum level the water becomes septic and immediately highly objectionable
-- total phosphate may also be considered an aesthetic characteristic, since an over-abundance of this material leads to formation of water flora often aesthetically unpleasant.

Criteria to control toxicity and/or irritability are fairly well-established, although for some pollutants the permissible levels are based more on aesthetic considerations.

Those characteristics dealing with toxicity and irritability are:

-- pH
-- temperature
-- chemical constituents
-- radioactivity
-- ammonia
-- phenols

All but pH are usually specified to conform to aesthetic criteria. Although temperature can be considered an aesthetic characteristic, there are certain limits for man-activities, especially regarding primary contact activities. Temperatures above 85°F begin to have physiological effects on man.[2]

The pH characteristic, a measure of the acidity-

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[2]Federal Water Pollution Control Administration, Interim Report of the National Technical Advisory Committee on Water Quality Criteria to the Secretary of the Interior, (Gold), Washington, D. C., June 30, 1967, p. 43, "Water Quality Criteria for Recreation and Aesthetics."

alkalinity of the water, is based on a range not causing irritation in the eyes of users.

> "In addition to sanitary criteria, the Committee recommends criteria on pH for primary contact recreation waters. While the Committee recognizes that many waters (marine, naturally alkaline or acidic fresh waters) cause eye irritation, the relation of pH to eye irritation justifies inclusion of pH criteria to enhance recreation enjoyment where pH can be controlled.
>
> "In the light of its coordinate effect, the buffering capacity should be considered in criteria to prevent eye irritation.
>
> "The lacrimal fluid of the human eye has a normal pH of approximately 7.4 and a very high buffering capacity, due primarily to the presence of buffering agents of the complex organic type. As is true of many organic buffering agents, those of the lacrimal fluid are able to maintain the pH within a very narrow range until their buffering capacity is exhausted. When the lacrimal fluid, through exhaustion of its buffering capacity, is unable to adjust the immediate contact layer of a fluid to a pH of 7.4, eye irritation results. A deviation of no more than 0.1 unit from the normal pH of the eye may results in discomfort. Appreciable deviation will cause severe pain. . . .
>
> "<u>Recommendation</u>
>
> "In primary contact recreation waters, the pH should be within the range of 6.5 - 8.3 except when due to natural causes, and in no case shall be less than 5.0 nor more than 9.0. When the pH is less than 6.5 or more than 8.3, discharge

> of substances which would increase the buffering capacity of the water should be limited."[3]

Criteria to control pathogenic organisms are based on the relative concentration of coliform bacteria. Empirical studies of contamination levels and incidence of disease have led to the use of this measure. Although in Massachusetts the bacteria analyzed include all coliforms, there is growing pressure towards the use of fecal coliforms (those bacteria arriving from human excreta) as more accurate and dependable.[4]

As regards man, it is evident that most water-quality criteria serve only to indicate threshhold levels of pollutants. In fact, except for relatively well-defined permissible levels for pathogenic organisms and irritants, water quality "standards" depend largely on aesthetic values.

Water quality plays a much more critical role for fish and wildlife, especially the former. Fish have no recourse but to survive in the water. Their critical relationship to quality criteria, then, is much more

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[3] Ibid. See also Appendix I of that chapter for an article by Eric W. Mood, MAH, entitled "The Role of Some Physical Chemical Properties of Water as Causative Agents of Eye Irritation of Swimmers."

[4] Federal Water Pollution Control Administration, Interim Report of the National Technical Advisory Committee on Water Quality Criteria to the Secretary of the Interior, (Gold), Washington, D.C., June 30, 1967, p. 39, "Water Quality Criteria for Recreation and Aesthetics."

sensitive to fluctuations. The concept of a "threshhold" level for quality characteristics begins to lose meaning when applied to the delicate ecology of the water itself.

SPACE, ACCESS AND LAND FACILITIES

Even with an adequate level of water quality, whether or not an activity occurs (and if so, to what extent) often depends as well on other factors. The most prominent of these are space requirements--space "standards," as it were, and accompanying characteristics of adjacent land.

To derive space requirements is largely a geometric procedure, modified by empiric observations. It is expected that no two agencies would arrive at the same "standards." Places with a relative abundance of space suitable for water-based recreation activities will probably enumerate "standards"--i.e., optimum (or minimum) per person space, noticeably higher than areas less generously endowed and/or more crowded.

Moreover, certain activities pre-suppose other conditions when "space standards" are given. In the case of swimming, for example, an acceptable beach and water bottom is assumed. Another example, power boating, assumes the absence of dangerous obstacles in the vehicle path.

All activities require some degree of public access. But the nature of this requirement may differ markedly. Swimming, for example, may require a relatively small area of intensively-used land and water. Boating, on the other hand, may require only point access to public areas, but the water surface itself may be extensively used.

All of these requirements are to an extent arbitrary. To enunciate "minimum" or "optimum" conditions is not to say that areas failing these characteristics never support activities. One frequently finds groups of children (and sometimes adults) bathing in "polluted" water. Boating, also, often occurs despite an objectionable water quality. An example close at hand is the boating activity in the Charles River Basin. Water quality "standards" rate the basin as relatively undesirable for this activity, yet already serious problems of overcrowding exist.

What is considered adequate space for an activity is likewise not always the same as the space actually available for an activity. To say that a beach is at capacity because of a per person "minimum standard" is not always valid, for people will adjust their demands to the resources available--they will demand more space when the areas are superabundant and will be satisfied with steadily less and less space if there is a dearth

of suitable areas. This is not to say that standards as such have no meaning. To say that people will adjust to less and less is not the same as saying that there are no space (and quality) objectives worth striving towards.

It is generally recognized that there do exist fairly well-defined space standards for some activities--standards which aim at insuring an acceptable level of comfort, safety, pleasantness, and facility for the participants while at the same time preserving the resource in a relatively unspoiled condition. Moreover, the use of "standards," even if they are approximate, serve a useful planning purpose, for these characteristics have to be known to give at least an approximate picture of the ability of an area to accommodate activity. Consequently, "standards" will be used in this study. Their use provides the most convenient common denominator from which to talk.

INTERFERENCE BETWEEN ACTIVITIES

Once space standards are recognized as important in determining the magnitudes of a given activity which may occur on a water body, it is clear that the occurrence

of one activity may preclude, or at least interfere with, other activities. For example, swimming and power boating quickly interfere with each other as the two activities share a progressively smaller area. Swimming areas must have an adequate measure of safety from the movement of power boats, and since there is a large measure of overlap in time of use for these activities, they are in conflict.

On the other hand, an activity like fishing, although occurring in the same areas as boating and swimming, does so at different times. While these other activities occur in the daylight hours of the warm season, especially summer, fishing activity is the greatest during the spring and fall seasons. During the warm season, what fishing activity there is occurs primarily in the early morning, late afternoon, and evening. In general, then, while most kinds of water-oriented recreation occur at the same times and hence tend to interfere with each other, fishing does not, thus complementing other uses.

LIMITATIONS OF DATA

As already pointed out, all of the space and water quality characteristics are, to some degree, arbitrary. The space, access, and land facility requirements presented in Tables 6 through 13 are no exception. Furthermore, they are only a summary of the space, access, and

land facility requirements from a variety of essentially unrelated sources. As such, there are some conflicting figures and alternative methods of describing identical requirements.

SECONDARY-CONTACT ACTIVITIES
Non-Power and Power Boating

Secondary water-contact activities under consideration are power boating and non-power boating. Although both have the same quality requirements, there is noticeable variation in space and access requirements.

WATER QUALITY

The water quality parameters are the same for both non-power and power boating. Those for Massachusetts are given in Table 5. Although the coliform content is not specified quantitatively, in order for water to be reasonably safe for man against occasional splashing and swallowing this standard would be in the range of 2000-3000 per ml. maximum.[1] The dissolved oxygen criterion, on the other hand, is only indirectly connected to the suitability for boating activity. That the dissolved oxygen level be always above zero would be sufficient, for (besides the fact that low dissolved oxygen levels indicate other pollution) at least some oxygen is necessary to prevent the water from becoming septic and offensive. The pH and radioactivity requirements coincide

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[1] Jack Edward McKee, Water Quality Criteria, Sacramento, State Water Quality Control Board, 1963.

TABLE 5

MASSACHUSETTS WATER QUALITY CRITERIA FOR BOATING
(QUALITY LEVEL "C")

Parameter	Criteria
coliform bacteria	none in such concentrates that would impair any usages specifically assigned to this class, and none that would cause taste and odor to edible fish.
pH	6.0 - 8.5
Radioactivity	none in concentrations or combinations which would be harmful to human, animal, or water use. None in such concentrations which would result in radio-nuclide concentrations in aquatic life which exceed the recommended limits for consumption by humans.
dissolved oxygen	not less than 5mg/l during at least 16 hours of any 24-hour period nor less than 3mg/l at any time. For seasonal cold water fisheries at least 5mg/l must be maintained.
sludge deposits - solid refuse - floating solids - oils - grease - scum	none allowable except those amounts that may result from the discharge from waste treatment facilities providing appropriate treatment.
color and turbidity	none in such concentrations that would impair any usages specifically assigned to this class.
taste and odor	none in such concentrations that would impair any usages specifically assigned to this class, and none that would cause taste and odor to edible fish.
allowable temperature increase	none except where the increase will not exceed the recommended limits on the most sensitive receiving water use and in no case exceed 83°F in warm water fisheries, and 68°F in cold water fisheries, or in any case raise the normal temperature of the receiving water more than 4°F.

TABLE 5 - Continued

Parameter	Criteria
chemical constituents	none in concentrations or combinations which would be harmful or offensive to human, or harmful to animal or aquatic or any water use specifically assigned to this class.
total phosphate	not to exceed an average of 0.05 mg/l as p during any monthly sampling period.
ammonia	not to exceed an average of 1.0 mg/l as N during any monthly sampling period.
phenols	not to exceed an average of 0.002 mg/l at any time.

SOURCE: Commonwealth of Massachusetts, Water Resources Commission, Division of Water Pollution Control.

with those levels suitable for fish and aquatic life. Generally, however, most of the water-quality requirements are based on aesthetic values.

Non-power boating does not affect appreciably the water quality characteristics of the host waters. Power boating, on the other hand, may itself affect the quality characteristics. Oil and gasoline spills may become noticeable. Intense power boating activity may increase the turbidity of the water and disturb bottom characteristics, especially at shallow depths. Taste and odor could thus be affected, which in turn might affect the desirability of the water for swimming and boating activities and the suitability of the water for fish and wildlife.

Boating in general is far more sensitive to space and access characteristics than to water quality. Except for minimum acceptable (or maximum tolerable) levels of a few pollutants for health reasons, most of the quality characteristics are based on aesthetic values. Whether boating activity occurs--and if it occurs, to what extent --is strongly determined by the physical form in which the water area occurs. Although row-boats, canoes, and small sailboats are flexible in their space requirements, power boating requires from one to twenty acres of water

area per boat, the water depth must be greater than some minimum safe figure, and must be free from dangerous obstacles. Furthermore, parking and launch facilities require land areas large enough for these functions. Finally, if all or some of the boats are to be moored, suitable and sufficiently large moorage areas require still further surface area.

WATER QUANTITY: SPACE REQUIREMENTS

Table 6 is drawn from a compilation of recreation area and facility space standards "currently being used by many organizations throughout the United States" prepared by the Bureau of Outdoor Recreation. It is again pointed out that the several "standards" put forth are drawn from usually unrelated sources. The figures should not be taken as absolute but rather as indicators to determine relative capacities.

Surface requirements for non-power boating are extremely flexible. For sailboats, the Soil Conservation Service recommends three acres per boat, but for small boats like rowboats, canoes, and small power (outboard) boats, far less than the enumerated standards are satisfactory. This is because the standards no doubt pertain to the larger and faster boats associated with the more

TABLE 6

SUMMARY OF WATER QUANTITY REQUIREMENTS
FOR BOATING

Sailboats		
3 acres per boat	119	Soil Conservation Service, Recreation Memorandum--3
Canoeing		
1/2 mile of stream per canoe. larger streams can hold one canoe per 1/4 mile (no quantitative cut-off sizes offered)	135	Comprehensive Plan for Wisconsin, Outdoor Recreation
	63	Louisiana Parks and Recreation Commission
Power Boating		
1 acre per boat	31	Corps of Engineers, Report on Grand Chariton and Little Chariton Rivers
3 acres per boat	119	Soil Conservation Service, Recreation Memorandum--3
20 acres per boat	135	Comprehensive Plan for Wisconsin, Outdoor Recreation
	63	Louisiana Parks and Recreation Commission

SOURCE: Bureau of Outdoor Recreation, Outdoor Recreation Space Standards, Washington: Department of the Interior, April 1967.

popular aspects of boating--i.e., boating "for fun" and water skiing.

An especially wide range appears in the area requirements for power boating, spreading from one acre per boat (U.S. Army Corps of Engineers, Design Criteria for Recreation Requiring Water Surface: Grand Chariton and Little Chariton Rivers Report) to 20 acres per boat (Louisiana Statewide Comprehensive Outdoor Recreation Plan and A Comprehensive Plan for Wisconsin, Outdoor Recreation). Several factors may account for this range. The first is different concepts of adequacy. There might also be different a priori assumptions regarding the types of craft that will use the waters. The most likely explanation lies in the fact that the low per-boat requirement originated in a document prepared specifically for a unique area, by an agency ever conscious of public benefits to be derived from its projects and ever in need to justify them.

For canoeing on a stream, that the Wisconsin Department of Resource Development recommends a minimum flow indicates that there must be depth adequate to float the craft and width sufficient to allow some maneuvering. Depending on the size of the stream (which size was not explicitly stated) 1/4 to 1/2 mile of stream per canoe is recommended.

STORAGE

For moored boats, 100 spaces are required for each 160 acres of boating water. Again, most of these standards apply to power boats, but would apply as well to sail boats if they are of the type too large to hand-transport.

LAND FACILITIES AND ACCESS

Generally non-power boating is a water-extensive activity in that this activity usually spreads atop a water body with few intensively used areas. But space requirements and access areas cannot be overlooked in determining the potential level of this activity. Where small rowboats are kept, say, at private camp areas, this space is little noticed, for it is usually easy to select space otherwise idle. But in the case of public areas, the problem of water-access becomes noticeable; not only in the case of relatively large sailboats, but for smaller boats and canoes. Table 7 summarizes these requirements.

Where trailered boats must be accommodated, launching ramps must be available. Recommended sizes are in the 1 1/2 acre range. How many such lanes are needed and, in fact, the capacity of such lanes, vary according to the reference cited. Some assume an *a priori* intensity of use for a water body and specify ramp capacity as a function of surface area. Others deal directly with the

TABLE 7

SUMMARY OF LAND FACILITIES AND STORAGE REQUIREMENTS FOR BOATING

Launch Facilities:

BASED ON SURFACE AREA OF WATER		
1 launch facility per 160 surface acres of boating water. parking space for 75 autos and boat trailers for each launching facility	21	California Public Outdoor Recreation Plan
1 boat access unit capable of launching one boat at a time, serving 125 trailored boats		
1 launching ramp per 150 acres of water	10	Statewide Comprehensive Outdoor Recreation Plan for Arkansas
ramps generally service 160 surface acres of water available for boating. each ramp has at least one 75-foot vehicular turn around	45	Federal Power Commission, Report on Criteria and Standards for Outdoor Recreation Development at Hydroelectric Projects
BASED ON NUMBER OF BOATS TO BE HANDLED		
1 ramp on 1 1/2 acres for every 125 boat owners if boaters average 8 trips a year. 21,000 sq. ft. of parking space per ramp	12	Baltimore County, Waterfront Recreation Survey
40 boats per lane of launching ramps. parking area for 40 cars	31	Corps of Engineers

TABLE 7, Continued

	45	Federal Power Commission, Report on Criteria and Standards for Outdoor Recreation Development at Hydroelectric Projects
	97	Nevada Department of Conservation and Natural Resources, Recreation in Nevada
1 boat launching lane per 25 boats	110	Proposed Public Outdoor Recreation Commission Plan, County of Placer, California
a boat ramp plus parking occupies 1 acre of ground space and can accommodate launching and retrieving of about 40 boats per day per launching lane; 60 cars with boat trailers can be parked in area	63	Louisiana Statewide Comprehensive Outdoor Recreation Plan, Supplement 1.
Storage for non-trailered boats		
moorage or slippage space for 100 boats at one time need 160 acres of boating water. parking space to park 50 autos for each 100 moored boats	21	California Public Outdoor Recreation Plan

SOURCE: Bureau of Outdoor Recreation, Outdoor Recreation Space Standards, Washington: Department of the Interior, April 1967.

number of boats to be served. Estimates of ramp capacities range from 25-125 boats. These estimates refer primarily to power boats which are not capable of being car-topped and hand-transported. For non-power boats, canoes, and sailboats capable of being carried to water, these requirements become overly large.

PARKING

Whether boats are moored or launched, parking for the users must be provided. In the case of trailered boats, this includes space for trailer storage.

COMPETITION WITH OTHER ACTIVITIES

The operating characteristics of power boats act to discourage other activities from occurring simultaneously. It becomes dangerous, for example, to remain in a stationary boat, or to swim, because of the possibility of a collision. Further, the noise and general disturbance impart a dominant quality to the environment, and/are especially disturbing to fish and wildlife.

BOATING AS AN ACCESSORY

Although sailing and canoeing are activities in themselves, a noticeable part of canoeing activity, and perhaps most row-boating activity, is performed as an accessory to another activity, the most important of which is fishing.

If this type of boating activity is to occur, then, the water must first be capable of supporting an adequate fish population. In most cases, water suitable for boating is also suitable for fish life.

PRIMARY-CONTACT ACTIVITIES

Swimming
Water Skiing

Primary water-contact activities under consideration are swimming and water skiing. Although water quality characteristics are the same for both activities, space requirements are basically different. Swimming is space intensive, while water skiing is space extensive.

WATER QUALITY

Table 8 gives the Massachusetts standards for water of a quality suitable for primary water-contact activities. Because of the likelihood of swallowing water, quality parameters are higher for primary-contact activities than for others. The coliform standard is explicit and more stringent than for secondary contact activities, and the pH standard narrows the permissible range of acidity-alkalinity. Finally, the overall aesthetic criteria are higher.

Swimming activity may itself alter some of the water quality parameters, especially at high intensities of use. The coliform count may be raised, refuse may increase, and there may be a local temperature rise. Turbidity may increase, accompanied by taste and odor problems.

TABLE 8

MASSACHUSETTS WATER QUALITY CRITERIA
FOR SWIMMING AND WATER SKIING
(QUALITY LEVEL "B")

Parameter	Criteria
coliform bacteria	Not to exceed an average value of 1000 during any monthly sampling period nor 2400 in more than 20% of samples examined during such period.
pH	6.5 - 8.0
radioactivity	None in concentrations or combinations which would be harmful to human, animal or aquatic life for the appropriate water use. None in such concentrations which would result in radio-nuclide concentrations in aquatic life which exceed the recommended limits for consumption by humans.
dissolved oxygen	Not less than 75% of saturation during at least 16 hours of any 24-hour period and not less than 5 mg/l at any time.
sludge deposits-- solid refuse-- floating solids-- oil--grease--scum	None allowable
color and turbidity	None in such concentrations that would impair any usages specifically assigned to this class.
taste and odor	None in such concentrations that would impair any usages specifically assigned to this class and none that would cause taste and odor in edible fish.

TABLE 8 - Continued

Parameter	Criteria
allowable temperature increase	None except where the increase will not exceed the recommended limit on the most sensitive receiving water use and in no case exceed 83°F in warm water fisheries, and 68°F in cold water fisheries, or in any case raise the normal temperature of the receiving water more than 4°F.
chemical constituents	None in concentrations or combinations which would be harmful or offensive to human, or harmful to animal or aquatic life or any water use specifically assigned to this class.
total phosphate	Not to exceed an average of 0.05 mg/l as P during any monthly sampling period.
ammonia	Not to exceed an average of 0.5 mg/l as N during any monthly sampling period.
phenols	Shall not exceed .001 mg/l at any time.

SOURCE: Massachusetts Water Resources Commission, Division of Water Pollution Control.

There is probably less of an effect from water skiing. The contamination that exists gets diluted beyond detection. Since a power boat is used for this activity, there may be some oil or gasoline spills noticeable. There would be less chance of increasing turbidity, for safety considerations would preclude this activity from shallow waters. Although these side-effects are generally temporary, they may lower the quality of the experience during times of peak use.

WATER QUANTITY--SPACE REQUIREMENTS

Table 9 shows surface area requirements for swimming. Depending on the reference cited, each person in the water requires from 100 to 200 square feet of water surface. Average surface area per person at the swimming area is 50 to 100 square feet of water surface.

Table 10 shows surface area requirements for water skiing. Extensive surface area is especially important for this activity, because of the requirements of safety and maneuverability. The recommended standards range from 1 to 40 acres per boat, but the one-acre-per-boat standard is supplied by the Corps of Engineers for a specific project and is suspect for the same reasons given on page 45. Similarly, the Soil Conservation Service recommendation of 5 acres may be conservatively small.

TABLE 9

SUMMARY OF SPACE STANDARDS
FOR SWIMMING

Water Area	
PER PERSON AT BEACH	
50 sq.ft.	21 California Public Outdoor Recreation Plan
50-100 sq.ft	87 National Recreation and Park Association
PER PERSON IN THE WATER	
150 sq.ft	128 Texas Statewide Comprehensive Outdoor Recreation Plan
100-200 sq.ft	119 Soil Conservation Service

SOURCE: Bureau of Outdoor Recreation, Outdoor Recreation Space Standards, Washington: Department of the Interior, April 1967.

TABLE 10

SUMMARY OF SPACE STANDARDS
FOR WATER SKIING

1 acre per boat	31	Corps of Engineers; Design Criteria for Recreation Requiring Water Surface; Grand Chariton and Little Chariton Rivers Report.
5 acres of water per boat	119	Soil Conservation Service
one person per 13.3 acres of water - estimate 3 persons per boat, 20 acres per boat may be adequate, but 40 acres per boat is more desirable	135	A Comprehensive Plan for Wisconsin, Outdoor Recreation
one ski boat requires 40 acres of water, therefore, 13 ski boats would require 520 acres of water to support one ski ramp	63	Louisiana Statewide Comprehensive Outdoor Recreation Plan

SOURCE: Bureau of Outdoor Recreation, Outdoor Recreation Space Standards, Washington: Department of the Interior, April 1967.

BEACH AND LAND FACILITIES

The water-bottom of the swimming area must be of a pleasant composition, preferrably sand.[1] Its slope into the water should be gentle, in order to provide a variety of water depths.

Besides the water itself, however, significant amounts of space are needed beside the water area. A "beach" area for sun-bathing is vital, as is space for parking, picnicking, and related facilities. Table 11 summarizes these requirements. The per person requirements range from 40 to 800 square feet. Although some of this variation can be explained by different attitudes towards the acceptable, a good deal of the variation is probably caused by the requirements for parking, picnicking, and buffer space. The relative amounts of picnicking and the ratio of people arriving by auto can make a large difference in the adjacent land requirements.

An alternative measure for the capacity of a swimming area is in linear feet of beach per user. The California Public Outdoor Recreation Plan recommends 25 effective feet of shoreline for each 1000 population. This accommodates 150 persons per day, and 50 persons at

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[1] Federal Power Commission, Report on Criteria and Standards for Outdoor Recreation Development at Hydroelectric Projects, Washington, D.C., Dec. 27, 1965, p. 24.

TABLE 11

SUMMARY OF SPACE STANDARDS
FOR SWIMMING AREAS

per person at area	150 sq.ft.	21	California Public Outdoor Recreation Plan
sunbathing	100 sq.ft.		
buffer, picnic	50 sq.ft.		
per person at area			
Urban Area:	500 sq.ft.	135	Comprehensive Plan for Wisconsin, Outdoor Recreation
sunbathing	100 sq.ft.		
buffer, picnic, parking	400 sq.ft.		
Rural Area:	800 sq.ft.		
sunbathing	200 sq.ft.		
buffer, picnic, parking	600 sq.ft.		
per person at area	40 sq.ft.	45	Federal Power Comm.
per person at area	50 -100 sq.ft.	119	Soil Conservation Service
per person not in the water	300 sq.ft.	128	Texas Comprehensive Outdoor Recreation Plan

SOURCE: Bureau of Outdoor Recreation, Outdoor Recreation Space Standards, Washington: Department of the Interior, April 1967.

one time. An effective foot is an idealized section consisting of one lineal foot of shore with a 100-foot wide band of water suitable for swimming, a 200-foot wide strip of beach for sunbathing, and a 100-foot wide buffer zone for utilities and picnicking. This would be the same as 50 square feet of water, 100 square feet of sunbathing area, and 50 square feet of utilities and picnicking space per person at the facility. It is seen that up to three times the land area as water area may be needed for a swimming facility, and even more land area may be needed if auto transportation is the usual mode of access.

Similarly, for water skiing, adjacent land and access facilities are important. Boat ramps and possibly boat moorage facilities are necessary for adequate access, along with space for car and trailer parking. The requirements are those for power boating in general.

FISHING
FISH AND WILDLIFE PROPAGATION

WATER QUALITY

The activities considered until now have been oriented solely to man. A study of the basis for water quality criteria as they relate to man has shown that relatively few factors relate to health and safety--most of the criteria are set to satisfy relatively subjective (and hence changeable) aesthetic criteria. Fishing, however, obviously depends on the presence of fish, so water supporting this activity must be favorable --at least tolerable--to fish.

In fact, two sets of criteria are applicable: one for man, and one for water life. While man must be aesthetically attracted to the water and have access to it, fish life must depend on a relatively well-balanced aquatic environment. Quality parameters which had been only aesthetic to man become matters of survival to fish life.

Considerable research has been conducted on the effects of various pollutants on aquatic life. There appears to be no simple relationship between water quality parameters and aquatic life. Rather the effects of any one pollutant depend not only on its magnitude, but on the state of the receiving water in general, the

time-concentration of the pollutant, and the presence of other pollutants.

> "The time-concentration relationship is very important in all studies of tolerances of aquatic and marine life toward pollutants. Thus, an organism may withstand a 10-minute exposure to 200 mg/l of a certain substance, followed by a return to clear water, without any apparent deleterious effect; yet the same organism may succumb to repeated 10-minute exposures of that concentration or to a continuous exposure to only 20 mg/l of the same substance. On the other hand, by continuous exposure to gradually increasing concentrations, the organism may build up a tolerance to concentrations that would be toxic to a non-acclimated organism. The effects of long-term exposures of fish populations to very low sub-lethal concentrations are not clearly understood.
>
> "This relationship of concentration and time of exposure is extremely important in considering the effect of a slug of waste on the aquatic life of a stream. Normally a slug would be more deleterious than a steady uniform discharge with adequate mixing, but in some instances the concentrated slug may be less detrimental than the steady weak pollution. Or, perhaps the lack of lateral or longitudinal mixing in a stream or tidal estuary may be advantageous if it produces a local concentration into which fish may swim accidentally, but from which they can escape to clear water in a few minutes without permanent injury.
>
> ". . .
>
> "It is impossible to set up rigid quality standards or limiting concentrations for broad general application over a wide area, because the many variable factors, both physiological and environmental, can alter the responses of fish

to specific constitutents of the water. Some of the most significant of these variables are considered in the paragraphs below.

"a. The effects of harmful substances upon fish life vary with species, size, age, and physiological condition of the individuals. Water favorable for some species may not necessarily be adequate for others that have been adapted to somewhat different conditions.

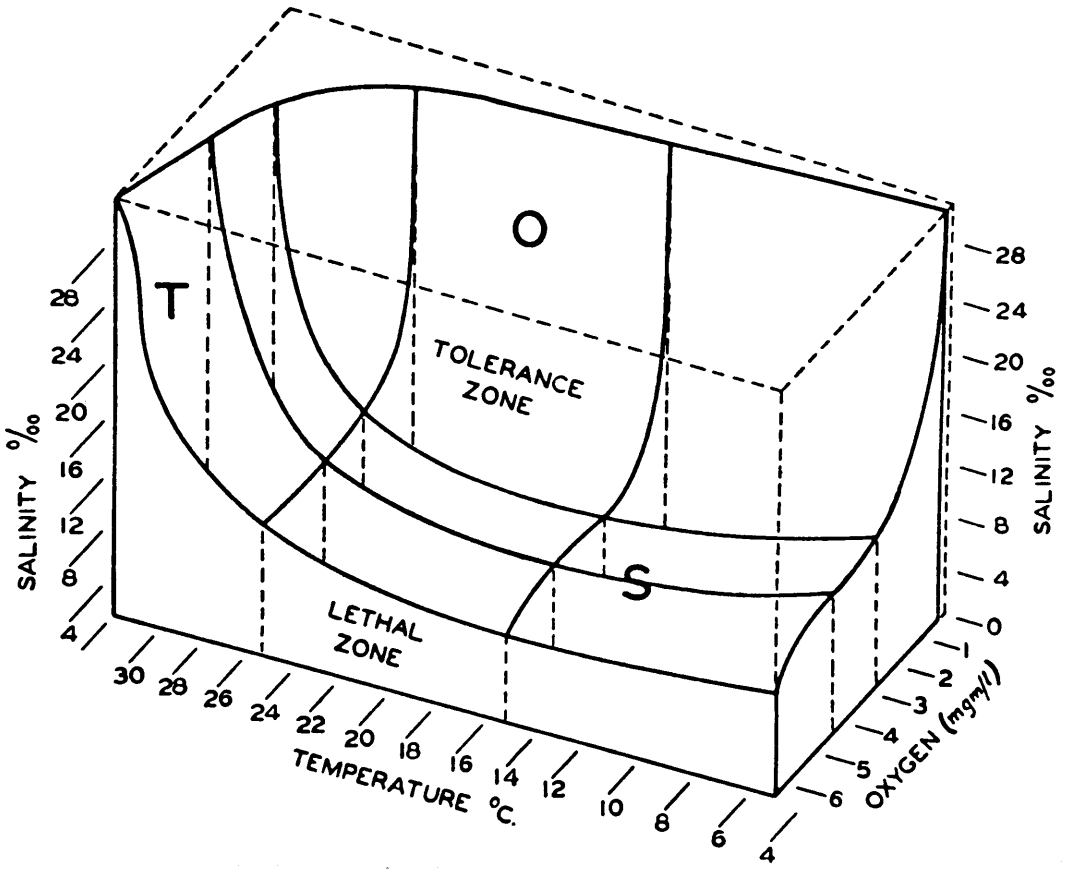
"b. The effects of deleterious substances upon fish vary with the physical and chemical composition of the water supply; for example, in soft water the damaging effects of poisons are generally greater than in hard water. In distilled water, very low concentrations of some pollutants are deleterious. Decreased oxygen concentrations and increased temperatures tend to increase the susceptibility of fish to toxicants. Interrelationships between the dissolved constituents of the water supply are also extremely important. By synergistic action, the combined influence of several substances simultaneously may result in greater damage to fish life than the sum of the individual effects taken independently. For example, a combination of sulfates of cadmium and zinc, or nickel and cobalt, are additive in effect, but combinations of sulfates of copper and zinc, copper and cadmium, or nickel and zinc can produce up to five times the reaction that would be expected if the effect were simply additive. On the other hand, certain combinations of salts act antagonistically to reduce the injurious effects of each. For example, mixtures of salts have become progressively less toxic when to sodium chloride solution has been added calcium chloride, then potassium chloride, and finally magnesium chloride. . . .

"c. Hydrographical features of water courses and fluctuating water

levels, particularly in impoundments, may also act to modify the effects of pollutants on fish in their natural habitats. . . ."[1]

FIGURE 1[2]

Diagram of the boundary of lethal conditions for lobsters in various combinations of temperature, salinity, and oxygen. T, region in which temperature alone acts as a lethal factor; S, region in which salinity alone acts as a lethal factor; O, region in which oxygen alone acts as a lethal factor.

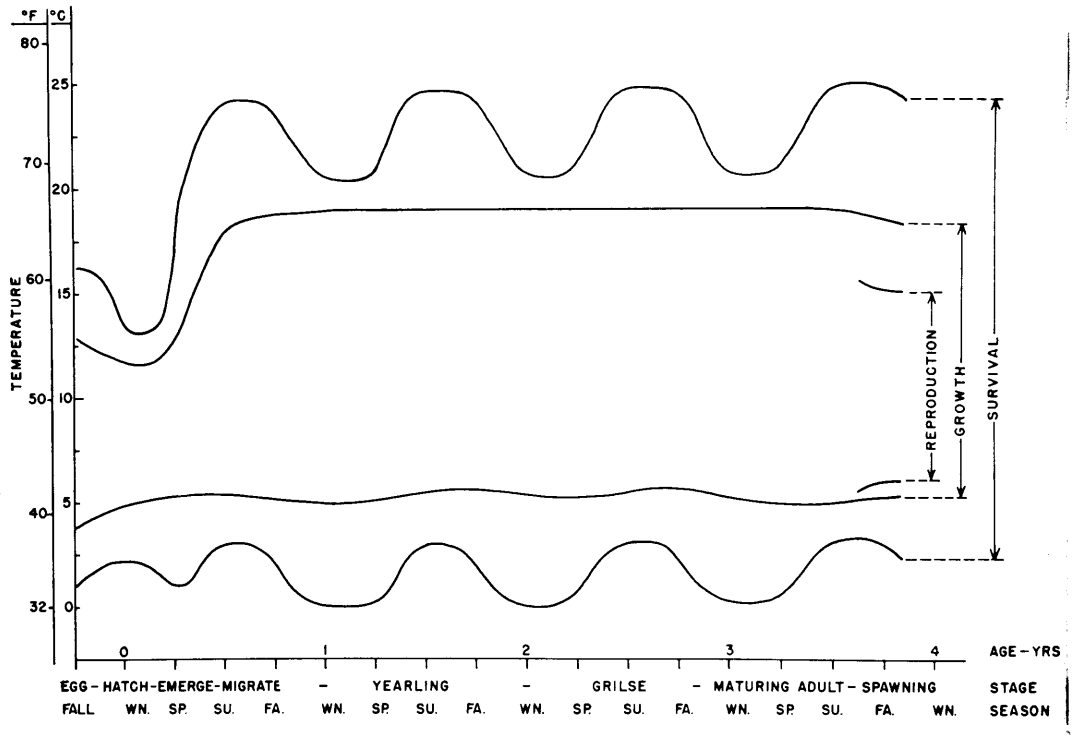


[1]Jack Edward McKee, Water Quality Criteria, Sacramento, State Water Quality Control Board, 1963, p. 114.

[2]American Fisheries Society, A Symposium on Water Quality Criteria to Protect Aquatic Life, Special Publication No. 4, Lawrence, Kansas: Allen Press, Inc., p. 28.

FIGURE 2[3]

Schematic representation of temperature requirements for different life processes of the Pacific salmon.



Work has been done in quantifying some of the water quality parameters as to their effects on fish life. For example, Figure 2 is a schematic representation of temperature requirements for different life processes of the Pacific salmon. But this only gives the requirements of

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[3]American Fisheries Society, A Symposium on Water Quality Criteria to Protect Aquatic Life, Special Publication No. 4, Lawrence, Kansas: Allen Press, Inc., p. 25.

one parameter. Figure 1 is a diagram of the boundary of lethal conditions for lobsters in various combinations of temperature, salinity, and oxygen. Because of the myriad combinations of pollutants which have yet to be studied, the possibilities of synergistic reactions, and the fact that several pollutants often occur simultaneously rather than two or three together, a more general set of criteria is needed for planning purposes. Freshwater criteria that will support a "good mixed fish fauna" have been presented as:

1. Dissolved Oxygen, not less than 5 mg/l (approximately the same as 5 ppm)
2. pH, approximately 6.7 to 8.6, with an extreme range of 6.3 to 9.0
3. Specific conductance at 25°C, 150 to 500 mhoX10^{-6}, with a maximum of 1000 to 2000 mhoX10^{-6} permissible for streams in western alkaline areas
4. Free carbon dioxide, not over 3cc per liter
5. Ammonia, not over 1.5 mg/l
6. Suspended solids such that the millionth intensity level for light pentration will not be less than 5 meters.[4]

These characteristics are favorable, and not merely sublethal, for a warm-water fish population. Incorporated in these characteristics are safety factors adequate to reasonably provide against synergistic actions.

It is criteria quite similar to these that are used

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[4] Jack Edward McKee, Water Quality Criteria, Sacramento, State Water Quality Control Board, 1963, p. 115.

for the least restrictive Massachusetts water-quality classification conducive to fish life, shown in Table 12.

For the propagation of other wildlife, water which is safe for secondary-contact activities (Massachusetts Class "C") is generally safe for wildlife.[5] Wildlife tolerance of pathogenic organisms and adjustments to pH are higher than for man. For wildlife, however, the accompanying land characteristics must be favorable. To be "favorable" depends on which types of wildlife species are considered. For specialized forms of hunting--e.g., ducks--swamps or marsh habitat is necessary. In general, a degree of relative seclusion is necessary; this becomes paramount if the purpose of the wildlife area is to provide hunting and trapping, not only for wildlife, but for safety considerations.

WATER QUANTITY

Assuming that favorable quality characteristics are indicative of a suitable aquatic environment, little else is required for fish propagation once water quality criteria are met. For man to enjoy this activity, however, consideration must be given to space requirements. Table 13 lists space requirements.

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[5] Ibid.

TABLE 12

MASSACHUSETTS WATER QUALITY CRITERIA
FOR FISH AND WILDLIFE PROPAGATION
(QUALITY LEVEL "C")

Parameter	Criteria
coliform bacteria	None in such concentrations that would impair any usages specifically assigned to this class.
pH	6.0 - 8.5
radioactivity	None in concentrations or combinations which would be harmful to human, animal, or aquatic life for the appropriate water use. None in such concentrations which would result in radio-nuclide concentrations in aquatic life which exceed the recommended limits for consumption by humans.
dissolved oxygen	Not less than 5 mg/l during at least 16 hours of any 24-hour period nor less than 3 mg/l at any time. For seasonal cold water fisheries at least 5 mg/l must be maintained.
sludge deposits-- solid refuse-- floating solids-- oil--grease--scum	None allowable except those amounts that may result from the discharge from waste treatment facilities providing appropriate treatment.
color and turbidity	None allowable in such concentrations that would impair any usages specifically assigned to this class.
taste and odor	None in such concentrations that would impair any usages specifically assigned to this class, and none that would cause taste and odor to edible fish.

TABLE 12 - Continued

Parameter	Criteria
allowable temperature increase	None except where the increase will not exceed the recommended limits on the most sensitive receiving water use and in no case exceed 83°Fin warm water fisheries, and 68°F in cold water fisheries, or in any case raise the normal temperature of the receiving water more than 4°F.
chemical constituents	None in concentrations or combinations which would be harmful or offensive to human, or harmful to animal or aquatic life or any water use specifically assigned to this class.
total phosphate	Not to exceed an average of 0.05 mg/l as P during any monthly sampling period.
ammonia	Not to exceed an average of 1.0 mg/l as N during any monthly sampling period.
phenols	Not to exceed an average of 0.002 mg/l at any time.

Class B and C waters shall be substantially free of pollutants that will:

(1) unduly affect the composition of bottom fauna

(2) unduly affect the physical or chemical nature of the bottom

(3) interfere with spawning of fish or their eggs.*

SOURCE: Commonwealth of Massachusetts, Water Resources Commission, Division of Water Pollution Control.

TABLE 13

SUMMARY OF SPACE STANDARDS
FOR FISHING

Stream Fishing		
1 mile of stream for every 10 persons	110	Proposed Public Outdoor Recreation Commission Plan: County of Placer, California
1 fisherman per mile (river fishing: 1 fisherman per 1/4 mile, approximately 3 acres per fisherman)	135	A Comprehensive Plan for Wisconsin, Outdoor Recreation
Boat Fishing		
Anchored: 1 acre of water surface for every 50 fishermen	31	Corps of Engineers, Design Criteria for Recreation Requiring Water Surface: Grand Chariton and Little Chariton Rivers Report
4 to 7 boats per acre	118	Soil Conservation Service, Book of Recreation References
Trolling: 2 to 4 boats per acre	118	Soil Conservation Service
Unspecified: 8 acres per boat	135	A Comprehensive Plan for Wisconsin, Outdoor Recreation
	63	Louisiana Statewide Comprehensive Outdoor Recreation Plan
RELATED REQUIREMENTS		
minimum surface area: 3 surface acres	118	Soil Conservation Service

TABLE 13, Continued

access: public fishing access area of 10 to 40 acres averaging at least 15 acres with 750 ft. of water frontage. One per 300 acres of water surface	127	Tennessee State Planning Commission, Public Outdoor Recreation Resources in Tennessee: Inventory and Plan for Development, 1962-?

SOURCE: Bureau of Outdoor Recreation, Outdoor Recreation Space Standards, Washington: Department of the Interior, April 1967.

It is recommended that from 1 to 10 fishermen can be accommodated per mile of stream and 1/50 to 8 acres is required per boat for boat fishing. The range of space requirements shown by these figures represents not only implicit assumptions regarding the size of a stream, but also incorporates varying values on isolation, size of lake, type of fishing, and other considerations. The importance of suitable access facilities is also evident: not only point access (boat launch facilities) but, in the case of shore fishing, overall access. Although a minimum public access area for shore fishing may be acceptable for lakes and ponds, for river fishing and especially in smaller streams nearly continuous public access is necessary for full use of the area.

REVIEW OF RECREATION AND CONSERVATION PARAMETERS

In general, then, the least restrictive classification for Massachusetts waters that allows active recreation use by man is Class "C", which is suitable for secondary-contact activities, like boating. For boating and fishing, other characteristics of the water area are necessary for the enjoyment of these activities.

Of special significance is the need for access points to the water, especially in the case of power boating and sailing, where hand-carrying is not practical. The need for parking facilities and/or boat moorage facilities indicates a need for relatively small--but intensively used--activity areas. Except for larger sailboats, the water area requirements per boat are quite variable; for non-power boating other than canoeing, the primary use of non-power boating is for fishing. For sailing, however, up to 3 acres per boat is recommended. For canoeing, a stream must first be navigable--then the recommended requirements range from 1/4 to 1/2 mile of stream per canoe, depending on--among other things--stream size.

For power boating the access requirements are more critical than those for non-power boating. The recommended surface area per boat ranges from 1 to 20 acres.

Because of the noise and general disruption caused by power boating, as well as safety considerations, activities which may accompany power boating are limited.

The Massachusetts classification least restrictive in providing primary water-contact activity is Class "B". Because of health and aesthetic factors associated with primary contact activities, quality standards are markedly higher and hence more difficult (and expensive) to attain. Activities in this category include swimming and water skiing.

Swimming areas are relatively high intensity use areas, and as such impose a dominant effect on a water area. With the inclusion of parking areas, beach area, buffer area, and picnic areas, the amount of space becomes noticeable. Among the characteristics swimming imposes on a landscape are, a suitable water bottom, beach area, and parking.

Water skiing is a relatively extensive water use, but requirements for power boating are often those for water skiing. Water access, parking, and boat storage are the most noticeable. The water-surface requirements are quite large, the recommendations ranging from 5 to 40 acres of water area per boat. This large area is required for maneuvering tow boats and providing for skier safety.

The last activity--fishing--should be considered in two different perspectives: There is the man-activity aspect; but there is also the fish and wildlife propagation aspect.

For man, fishing is much the same as boating in that the contact with the water is secondary. What interests him is primarily the quality of the fishing experience, which includes not only aesthetic characteristics but the type and amount of fish life. That fish are sensitive to practically all materials introduced to the water in extremely complicated and relatively unknown ways and degrees would be paralyzing to the planning process, were it not for the fact that maximum safe limits--even including the effects of synergistic reactions and allowing for safety factors--are within the limits of the characteristics specified by Massachusetts in class "C" water. As long as fishing is considered one of the most important--if not the most important--results of providing water suitable for fish propagation, this approximation is justified.

Although not as critically related to water quality as is fish propagation, some types of wildlife propagation should be included. The most important is waterfowl which is very dependent on water areas and suitable water quality. In general, water quality favorable to fish is

also suitable for waterfowl, but the accompanying land characteristics are a critical part of the environment.

CASE STUDY: THE CHARLES RIVER

NEED FOR A CASE STUDY

The preceding discussion of quality, quantity, access, and associated land parameters necessary for recreation and conservation uses is of a general nature, and in itself does not highlight the relative importance of water quality, access, space, and associated land characteristics. The possibilities offered by improved water quality and the limitations posed by space, access, and land characteristics are shown much more clearly by applying the general observations to a real area. Furthermore, the Charles River is an especially appropriate vehicle to illustrate that a program of water-quality improvement has to be based on the activities to be provided or enhanced, and must provide for control over all characteristics.

GENERAL

The Charles River basin was selected as a case study for several reasons. There is much interest in it on the part of private and public groups. There is a wealth of information on both the basin itself and the metropolitan area. Many agencies have jurisdiction or have an advisory role concerning sections of the river

encompassing several municipalities. Finally, large amounts of money are being spent or contemplated for water quality improvement of the Charles.

The linear length of the basin is approximately 80 miles, and meanders 31 miles inland. It is the largest of the three metropolitan rivers.

> "The Charles River Watershed in eastern Massachusetts is at the northeastern end of the 500 mile Atlantic coastal megalopolis, Boston to Washington. The Charles River Watershed extends 31 miles southwesterly from Boston Harbor toward Providence and Woonsocket, Rhode Island, and includes all or parts of five cities and thirty towns, in parts of four Massachusetts counties. The 1965 watershed population was about 850,000. The watershed is about 307 square miles in area and hour glass in shape; the length is 31 miles, and the widths are 15, 6 and 15 miles. Elevations vary from 560 feet, msl, along the southwesterly rim of the watershed in Milford and Hopkinton, to below 10 feet, msl, along the river through Watertown, Cambridge, and Boston."[1]

Historically, the river has long been used for recreation. In 1875 the Legislature authorized the city (Boston) to purchase land for parks and in 1877 the Park Commissioners moved to purchase the Fenway.

> "The next move, it is expected, will be the improvement of the strip known as the Charles River embankment,

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[1]Department of the Army, N.E. Division Corps of Engineers, Charles River Watershed Study: Status Report 1, January 1968, Waltham, Mass., Jan. 1, 1968, p. 2.

> beginning from Leverett Street and extending along the border of the Charles River to Cottage Farm Station, a distance of nearly 2-3/4 miles with an average width of 200 feet. . . . The plans contemplate a beautiful river side resort, which will add much toward making Boston what it is fast coming to be, the most attractive city on this continent. (King's Handbook of Boston, Boston, Mass. 1881)."[2]

Upstream at Riverside in Newton there was also intensive recreational use of the river. The Tercentenary History of Newton describes the scenes.

> "As summer approached in 1897 the Charles River Navigation Company proposed to inaugurate a service on the river for those who wished to enjoy outings. It experimented first with steam launches for forty or fifty persons on the lower river, and intended later to provide pleasure boats along the length of the stream from Riverside to Boston Harbor with stops at various resorts. At that time Riverside was credited with the mooring of four thousand two hundred canoes. The Wawbewawa Canoe Association was the result of an interest in canoe racing. A racing canoe bearing the Indian name was launched on the Charles River in 1893, the first of its kind in New England. [The canoes] . . . were thirty feet long and would hold nine men each. The races were eagerly followed by the public . . .
>
> "Another event of that season was the opening of Norumbega Park on the seventh of June. It had been in process of construction for two years. To the

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[2]Metropolitan Area Planning Council, The Mystic, Charles and Neponset Rivers, Preliminary draft, undated, p. 29.

> natural grove had been added 200 trees, 500 shrubs, and 100 vines. Its proximity to the river added to its popularity and its 150 canoes and launches were quickly in demand. Its deer park of an acre or more, its rustic paths, its theater with seats for 1200 people, the merry-go-round, the daily band concert, and the beautiful effects of the electrical fountain in the center of an acre pond, proved a great attraction, not only to Newton people but to the inhabitants of Boston as well."[3]

Today, recreation is the predominant activity on the river. Recreational boating is extremely popular in the lower reaches of the River (the Basin). Upstream, recreation uses include canoeing, fishing, and swimming. Recreation uses of the river are increasing even with present water quality.

Table 14 and Figure 3 describe and illustrate the five segments into which the main stream is subdivided. Of these, Segments III, IV, and V are characterised by an upgrading of quality (as opposed to maintaining present quality). It is with these segments that the case study deals primarily.

METHODOLOGY

In addition to several studies dealing specifically with the Charles River, local, state, and Federal agencies had been consulted regarding their respective interests

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[3] Ibid.

TABLE 14

CHARLES RIVER BASIN CLASSIFICATION

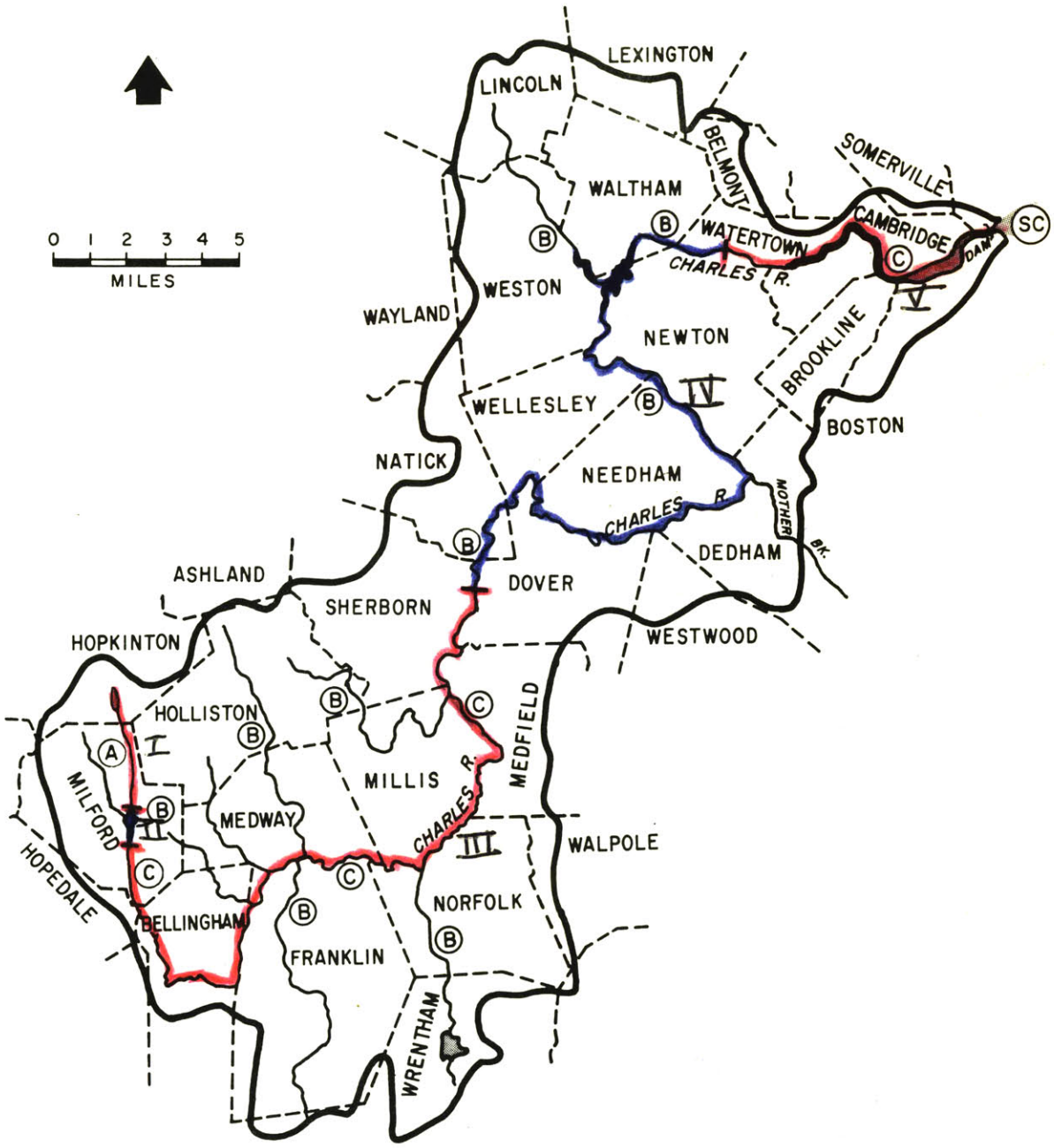
Segment	Present Use	Anticipated Future Use	Present Condition	Classification
The source to Dilla St. Milford (I)	Water Supply	Water Supply	A	A
Dilla St. Milford to Main St. Milford (II)	Bathing Fish & Wildlife Propagation Fishing	Same	B	B
Main St. Milford to Bridge St. Dover (III)	Recreational Boating Fish & Wildlife Propagation Fishing Assimilation	Same	D & C	C
Bridge St. Dover to Watertown Dam, Watertown (IV)	Recreational Boating Fish & Wildlife Propagation Fishing Assimilation	Same and Bathing	D & C	B

TABLE 14 - Continued

Segment	Present Use	Anticipated Future Use	Present Condition	Classification
Watertown Dam, Watertown to Charles River Basin Dam, Boston (V)	Recreational Boating Fish & Wildlife Propagation Fishing Assimilation	Same	D & C	C
Medfield-Farm Pond, Sherborn	Water Supply	Water Supply	A	A
All other streams in the Watershed unless denoted above	----	----	-	B

SOURCE: Commonwealth of Massachusetts, Water Resources Commission, Division of Water Pollution Control.

FIGURE 3



COMMONWEALTH OF MASSACHUSETTS
WATER RESOURCES COMMISSION

CHARLES RIVER BASIN

CLASSIFICATION

WATER USE CLASSES - (A) (B) (C) (D) (SB)

— CHANGE CLASSIFICATION

in the Charles. Two sources need special mention in order to qualify the information which they yield.

In order to determine evaluation of the relative importance of the parameters at the local level, a questionnaire was sent to the local conservation commissions of all towns touching upon Segments III and IV. In those towns which have no commission (Newton, Waltham) the questionnaire was sent to the Planning Department. A copy of the questionnaire is in Appendix II, with the list of municipalities responding. They were not sent to municipalities touching only Segment V, for data on this segment is well-documented. Neither were they sent to municipalities touching only upon Segments I or II. The first two segments are to undergo no quality changes so the question of new or expanded uses due to quality changes did not arise. Initially it was felt that the most valuable responses would be found in subjective check-off responses of Questions Nos. 1, 4 and 6. Subsequent evaluation of the returns, however, yielded far more interesting information from the open-ended questions (part of Questions Nos. 2, 4, 6 and 3, 5 and 7.) It should be emphasized that the responses were meant to be subjective. It was felt that not only would quantitive responses have been time-consuming thus ruling out most responses, but also those preparing them might have felt

to be committing the interests of their municipality in some way by offering the data (assuming they were capable of doing so or had a staff adequate to do so). Out of twenty questionnaires sent, eleven were returned.

That the questionnaire was sent to conservation commissions whose primary interests lie in recreation and conservation uses might have introduced some bias in over-stating the importance of water quality improvement. In retrospect, this did not seem to be the case.

In addition to the questionnaire, local responses were obtained through municipal master plans and recreation and conservation studies. A bias in under-stating the importance of water quality is suspected. Local communities have virtually no power to change the water quality as it enters the municipal boundaries, and must therefore consider this factor as exogenous.

For Segments III, IV and V, the information obtained from the questionnaire responses and master plans will be presented in downstream order. Where a bordering town is not mentioned, no return was received and/or there was no master plan.

CLASSIFICATION HEARING

In accordance with Section 27(4), Chapter 21 of the General Laws, and as required by the Federal Water

Pollution Control Act, as amended, the Massachusetts Division of Water Pollution Control held a public hearing on April 14, 1967, relative to, among other waters, those of the Charles River. After hypothetically applying secondary treatment to pollution sources, and simulating their effects on water quality, a staff recommendation was that the entire Charles River basin downstream of Milford be classified as "C".

Those being heard at the hearing were emphatically in favor of upgrading this classification. Not one spokesman requested anything lower. Moreover, 159 letters, 2 petitions representing 50 people and 12 telegrams were received, all in favor of a "B" classification for the Charles, and practically all of these were speaking for the middle reaches of the river. The final classification, shown in Figure 3 and Table 14, closely reflect the pressure which was put on the Division of Water Pollution Control for a high classification.

Although the motives for the spokesmen were doubtless sincere, there were only vague allusions to advantages. Several speakers mentioned the desirability of introducing (or re-introducing) swimming as an activity; but, as a global evaluation, there had been no meaningful assessment of recreational benefits accruing from water-quality changes.

SEGMENT III

Overview

This segment extends from Main Street Milford to Bridge Street Dover, and is approximately 30.8 miles long. Water is presently of "C" and "D" quality, but will be upgraded to be uniformly "C". The recreation and conservation uses to be enhanced are recreational boating, fishing, and fish and wildlife propagation. There are five dams dividing this segment into six lengths:

- Cedar Swamp Pond Dam to Box Pond Dam (5.2 miles)
- Box Pond Dam to North Bellingham Dam (4.1 miles)
- North Bellingham Dam to Caryville Dam (1.5 miles)
- Caryville Dam to West Medway Dam (1.7 miles)
- West Medway Dam to Medway Dam (2.1 miles)
- Medway Dam to South Natick Dam (19.8 miles) (part of this length is in Segment IV)

There are three noticeable impoundments in Segment III: Box Pond, formed by Box Pond Dam; an impoundment formed by the North Bellingham Dam; and Populatic Pond. Most of the area through which the river passes is swamp and marsh, especially past Populatic Pond. The average low month flow increases from 0.8 CFS at Main Street Milford to 15.4 CFS at Bridge Street Dover.[4]

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[4] William Butler, unpublished data on Charles River hydrology at the Federal Water Pollution Control Administration, Northeast Water Quality Management Center, Needham, Mass.

> "Studies of bottom-associated aquatic life, nutrients, aquatic plants, and river deposits showed water quality degradation and sludge deposits from wastes originating in Milford, Massachusetts and with additional waste contributions in downstream reaches, polluted conditions extended through Medfield, Massachusetts, a distance of 32 stream miles."[5]

Town-by-Town Summary

MILFORD -- The master plan takes note of the Charles, especially a section of Segment II--Cedar Swamp Pond. No particular mention was made of recreation activities but the value of the area for wetlands and wildlife was acknowledged.

The questionnaire response indicates that Cedar Swamp Pond provides the major part of all activity occurring on Charles River water in this municipality, which activities are boating and fishing.

HOPEDALE -- Although there is no master plan for Hopedale, the questionnaire responses are quite clear. Water quality improvements are not, and cannot be, significant. Rather the limiting characteristics are physical.

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[5]Federal Water Pollution Control Administration, Biological Aspects of Water Quality, Charles River and Boston Harbor, Massachusetts, Cincinnati: FWPCA, January 11, 1968, p. 1.

> "The Charles in this area is very small and not suitable for any of the above-mentioned uses. In fact, [in] most summers the river is dry in some sections."

BELLINGHAM -- The master plan made no mention of Charles River water-quality, nor of recreation or fish and wildlife propagation. Although conservation (and hence fish and wildlife propagation) benefits are implied, the emphasis is on the problems of preserving the adjacent land.

MEDWAY -- The master plan contains an admonishment to the town for dumping raw sewage into the river, but does not propose activities made possible from quality improvement.

The questionnaire indicates that physical characteristics are at least as important as quality in determining the possible activities. If water quality were markedly improved, swimming might be possible. But only if the physical characteristics of the area were modified.

> "For good swimming one or two of the old dams would have to be rebuilt. Normally [the] river is too shallow and narrow for development along these lines, although there are possibilities if water is cleaned up.
>
> ". . . No special facilities--River relatively shallow.
>
> ". . . Power boating is practically impossible because of depth of water, rocks and old dams that have been partly washed out."

FRANKLIN -- The master plan takes note of both existing recreation activities along the Charles, and possible expansion of these activities. Although there is no direct mention of water quality, provision of the following activities--"picnicking, boating, hiking, fishing, open play, and scenic values"--would be expanded by further acquisition of public land along the river. Populatic Pond, formed by the Charles, has public access for fishing.

NORFOLK -- The questionnaire responses indicate that the recreation and conservation activities are limited by water quality. In the subjective evaluation of activity intensity, no increases in activity were noted without a quality increase but a hypothesized upgrading to "C" quality gave increase in fishing, swimming, water skiing, and fish and wildlife propagation. The response further explains:

> "Improvement of water quality (in the marsh areas contiguous to Medfield-Millis areas which are extensive waterfowl nesting areas) would provide [an] excellent habitat for warm-water fish. This is a delightful stretch of river, retaining a naturalistic setting, but [the] water quality is, generally, of an offensive nature."

The master plan treats of the scenic value of the River for passive recreation, and also stresses the potentialities for boating, fishing, and "other sports" if pollution is controlled.

Because the water occurs in a more useful physical form at Populatic Pond, it is used for primary-contact recreation despite a relatively poor quality:

> "Summer residents are using class "C" and "D" water for contact recreation. From Populatic Pond downstream, phytoplancton concentrations are heavy, making swimming dangerous and aesthetically poor."

If the quality were raised to a uniform "C" level, the magnitude of swimming and water skiing would increase notwithstanding that the level should be raised still higher to "B" for these activities.

MEDFIELD -- That the topography is favorable to conservation activities is indicated through the questionnaire responses:

> "Area is ideal for wildlife breeding and shelter, and fish breeding (warm water species only)."

It is further made clear that water quality improvement would greatly increase the value of this use:

> "Area has ideal habitat for wildlife and gamefish indigenous to this region. Elimination of pollution and some mechanical control of spring flooding would greatly improve this facility."

> "Fishing . . . is ideal for fish indigenous to region, but water quality is so polluted by June 30 that many fish are destroyed (especially stocked trout)."

For all other activities the limitations are posed by the small quantity of water available, and physical characteristics in general:

> "Boating is light due to navigational hazards, debris, shallow areas, etc. Canoeing on decline."
>
> "Boating is fair till water height becomes low in June."
>
> "Boating and canoeing might improve if navigational hazards are removed."

Furthermore, the master plan places emphasis on land acquisition and does not consider the activities to be accommodated.

SHERBORN -- The proposed classification changes from "C" to "B" through this community, although in practice the change will be gradual.

Indications from the questionnaire responses are that increases in the magnitude of activity can occur without water quality changes. There is relatively more concern with the character and preservation of land adjacent to the water.

> "Almost [the] entire stretch of river in Sherborn is occupied by large farms or estates or Town Forest. This makes the area relatively wild and free from encroachment of houses."

That there is a highly superior alternative--Farm Pond--in this municipality, for swimming and other water-contact activities, diverts much attention from the Charles as a place for these activities.

DOVER -- The proposed classification changes from "C" to "B" as in the discussion of Sherborn. Here, also,

the primary concern is with conservation. There is more interest in land acquisition and regulation than in water quality changes. An inconsistency with the conservation objectives exists in the responses insofar as swimming was indicated as a possible activity.

Evaluation

Upgrading water quality in Segment III can increase recreation and conservation activities. The responses most often mentioned improvements in fishing and fish and wildlife propagation, as for Milford, Norfolk and Medfield. This observation is clear when the extensive marsh and wetlands in this segment are recalled, along with the fact that the parameters of a "C" quality level are adequate to support a healthy aquatic and wildlife environment.

Notwithstanding a water quality markedly damaged by periodic occurrence of sewerage outfalls,[6] Table 15 indicates the relatively high degree of use Segment III receives, and the relatively high degree of productivity over Segments IV and V. There are more annual hunter trips here (11,700) than either Segment IV (100) or Segment V (none). Bird and nature study trips are much more frequent here (3,500) than the other Segments

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[6] Ibid.

TABLE 15

ESTIMATED FISH AND WILDLIFE RECREATION ON CHARLES RIVER, 1968

	Est. Annual Angler Trips	Est. Annual Hunter Trips	Est. Annual Trapping Days	Est. Annual Bird and Nature Study Trips	Est. Annual Harvest Fish, Fur & Game	
Segment III	Trout 1,000 Other 2,000	Waterfowl 1,200 Misc. Game Mammals 500 Pheasant 10,000	100	3,500	lbs.fish pelts fur game birds game mammals	3,500 1,000 1,000 1,000
Segment IV	Trout 500 Other 500	Waterfowl 50 Misc.Game 50	50	1,000	lbs.fish pelts fur game birds game mammals	600 250 20 50
Segment V	Trout (none) Other 100	none	none	100	lbs.fish	50

SOURCE: Paul S. Mugford, State Ornithologist, Commonwealth of Massachusetts, Division of Fisheries and Game, April 15, 1968.

(1,000 for IV; 100 for V). And the annual harvest for fish, fur and game are respectively: 3,500 lbs, 1,000 pelts, 1,000 game birds, and 1,000 game mammals for Segment III; 600 lbs, 250 pelts, 20 game birds, and 50 game mammals for Segment IV; and 50 lbs of fish for Segment V.

Although the data does not directly show effects of water quality improvement, an indication can be drawn from the projections with and without water quality improvements. Projections for 1980 indicate a 10 per cent increase in fish and wildlife activity with no quality change, and a 100 per cent increase if the quality is up-graded to a uniform "C". Projected increases for 2000 are the following:

PER CENT INCREASES, 1968-2000

	present quality	with uniform "C"
trout fishing	100	200
other fishing	80	200
hunting, trapping	10	50

Although increased fish and wildlife activity should occur with present quality, improvement of these parameters will, in turn, improve and increase these activities. Once a "C" level is achieved, however, further improvement in quality would not markedly increase the

productivity.[7] Appendix III contains the entire table as received from the Department of Natural Resources.

If the major emphasis is on conservation values, it follows that much attention would be given to gaining public control over these water-land areas. Such is the case with the emphasis placed on this segment by the Metropolitan Area Planning Council:

> "In the upper Charles, open and rural land use still predominates although there are pockets of quite intensively developed suburban housing.
>
> ". . . The danger is that land along the river, its tributaries and the associated swamps and wet areas will be lost by attrition; lot by lot development will proceed in the absence of a public open space conservation and recreational program. At the same time the few remaining private open areas will be forbidden to any public use and the river will, in effect, be closed.
>
> ". . . The community master plans almost consistently ignore the open space and recreational potential of the river and sanction, implicitly or explicitly, the diversion of river bank and wetlands for residential, commercial and industrial development."[8]

Other responses, as in those for Hopedale, Medway,

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[7] Paul S. Mugford, State Ornithologist, Commonwealth of Massachusetts, Division of Fisheries and Game, 4-15-68.

[8] Metropolitan Area Planning Council, The Mystic, Charles and Neponset Rivers, Preliminary draft, undated.

and Medfield, recognized the limitations set by space and access characteristics on activities otherwise possible on "C" quality water. The limitations were especially severe for power boating, but also were evident for swimming (notwithstanding the inappropriate water quality).

There are three noticeable impoundments in this Segment: Populatic Pond (225 acres), Box Pond (41 acres), and that formed behind the North Bellingham Dam (7 acres) for a total of 273 acres.

If devoted to boating, approximately 90 boats could be accommodated at these places (on the basis of 3 acres per boat and assuming a mix of boat sizes and types). If swimming were to be possible (which would mean a quality change to that of "B") then 34,700 swimmers might be accommodated (on the basis of 1 linear foot of shoreline per person). The breakdown is as follows:

	Swimmers	Boats
Populatic Pond	17,600	75
Box Pond	15,200	14
N. Bellingham	1,900	2

These figures assume that both access characteristics and the associated land characteristics do not present any limitation. They are not realistic, for, especially in the case of swimming, access and adjacent land characteristics may in fact pose limitations to an otherwise full capacity.

At this time, the Corps of Engineers is studying the possibility of creating low-flow augmentation impoundments for the Charles, the most likely locations of which are in the upper reaches of the river.

> "Consideration is being given to single and multiple-purpose storage reservoirs on the Charles and its tributaries. Storage may be used to provide improvement for fish and wildlife, for recreation, for water supply, for low-flow augmentation and for flood control."[9] (Emphasis supplied)

Creation of new impoundments would further increase these figures. Depending on the recreation and conservation objectives, the availability of these additional impoundments could be a strong determinant for reconsidering the present water quality classification. If swimming facilities are sorely needed, several new facilities could be established at this Section but would require a further upgrading to a "B" quality. Otherwise, some contribution to the boating needs could be made by the present classification. The present "C" classification would, of course, be favorable for fish and wildlife propagation (and hence fishing).

Should intensive swimming activity be established,

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[9] Department of the Army, N.E. Division Corps of Engineers, Charles River Watershed Study: Status Report 1, January 1968, Waltham, Mass., Jan. 1, 1968, p. 3.

the effect might be to noticeably disrupt the use of this segment for fish and wildlife propagation.

A more complete discussion of the factors which must be considered for a decision on this point is found on pages 123-124.

SEGMENT IV

Overview

Extending from Bridge Street Dover 34.0 miles downstream to Watertown Dam Watertown this segment, presently of "C" and "D" quality, is to be upgraded to "B". The river passes through a variety of topography, most notably the extensive Dedham marshes and several impoundments, among which are Red Wing Bay, Cow Island Pond, and Norumbega Park. There are ten dams along this segment. The proposed uses for this segment include those for segment III--recreational boating, fish and wildlife propagation, and fishing--and also swimming. Average low monthly flow fluctuates from 15.40 CFS at Bridge Street Dover to 25.80 CFS at Watertown Dam Watertown.[10]

In general, the quality of water in this segment is higher than that for Segment III:

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[10] William Butler, unpublished data on Charles River hydrology, at the Federal Water Pollution Control Administration, Northeast Water Quality Management Center., Needham, Mass.

> "Improved conditions . . . existed from South Natick to Wellesley . . . as evidenced by a predominance of clean water bottom animals; however, nutrients from upstream sources caused dense growths of rooted aquatic plants and phytoplankton in the improved reaches."[11]

Town-by-Town Evaluation

WELLESLEY -- The master plan contains a proposal for a park and a greenway along the River, but there is no mention of water-oriented activity. The emphasis is on land acquisition.

NEEDHAM -- The master plan contains several recommendations for land acquisition to enhance flood plain regulation and to provide additional facilities for boat access to supplement that at Red Wing Bay.

The questionnaire responses indicate that water quality improvement would permit swimming:

> "If the river were shown to be consistently of "B" quality, and people began to swim in the river, the frequency would increase, and water contact sports and recreation would expand."

NEWTON -- The master plan did not make specific recommendations of its own, but deferred to the recommendations of a basin-wide interest group--the Charles River Watershed Association (which is presently creating its

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[11] Federal Water Pollution Control Administration, Biological Aspects of Water Quality, Charles River and Boston Harbor, Massachusetts, Cincinnati: FWPCA, Jan. 11, 1968, p. 1.

own report). The importance of wise utilization of the river resources is made explicit.

WESTWOOD -- Although only a very small section of the river passes along its border, Westwood appears to be one of the more progressive municipalities regarding basin resource utilization. A recently-completed conservation plan (from MAPC) considers both quality and access characteristics. Although Westwood has only a small section of the Charles along its border, it has obtained from the MAPC a conservation plan. The principal recommendation is public access areas to the Charles. Although the report mentions swimming as a possible future use, those uses now possible and which need only public access are a hiking trail, canoeing (canoe launching), and fishing.

WESTON -- The master plan shows a strip along the Charles as "public lands," but makes no mention of water quality nor of any activities which might occur along its banks. The questionnaire response indicates that little use is made of this stretch of the river, save for the propagation of waterfowl.

WALTHAM -- The questionnaire responses indicate that, although quality does affect the activities possible, space requirements are at least equally important.

> "At present the river is too contaminated to be utilized for enjoyment

> purposes to any great degree. If the quality of water was raised to . . . [a "B" classification] . . . it could be used for . . . [swimming and water skiing] . . . but only to a limited degree because of natural restrictions."
>
> "This stretch of the river is unsatisfactory for power boating because of the limited area between the dams at Waltham and Watertown. . . ."
>
> "Non-power boating activities could be enjoyed in certain limited areas if there was a desire and facilities for such."

WATERTOWN -- The questionnaire responses indicate that the section of the river upstream of Watertown Dam is little used. The main problem seemed to be that of arousing public interest in this stretch.

Evaluation

Although there was more interest expressed for swimming activities, as in Needham, Waltham, and Westwood, there is far more concern over acquiring public access. Westwood is the best example of this relative emphasis.

The Metropolitan Area Planning Council puts primary emphasis on preserving and/or controlling the lands adjacent to Segment IV (as well as Segment III):

> "Above the Watertown Bridge, public control of the river bank is severely limited. Early plans for acquisition and control of the banks were never completed as proposed and the river is being squeezed by residential, commercial and industrial development as well as by incompatible public uses.

". . .

"It is expected that land use in the area between Watertown and Wellesley will be subject to severe pressures for increasing density in the next ten to fifteen years. . . .

"Some lands have been publicly acquired in this section of the river. The extensive marshlands in Dedham, Needham and Newton have been acquired by the Metropolitan District Commission as a public reservation. [Cutler Park] . . . But holding these wetlands open is only a small part of the total open space needs in the area.

". . .

"The danger is that the land along the river, its tributaries and the associated swamps and wet areas will be lost by attrition; lot by lot development will proceed in the absence of a public open space conservation and recreational program."[12]

Recommendations for an open space program consistently stress public control of the river lands. Furthermore, primary-contact activities would be only a small part of the uses anticipated.

"Riverside

"Because of its exceptional transit and highway accessibility the Riverside area is recommended as a major regional recreational facility. A central building housing a boat rental service, small nature museum and information center for various walking trail routes should be constructed. . . .

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[12]Metropolitan Area Planning Council, The Mystic, Charles and Neponset Rivers, Preliminary draft, undated, p. 37.

"Quinobequin Road

"The residential area along Quinobequin Road should not be disrupted by major recreational development. However, the existing open areas should be maintained in a natural state as pleasant scenic spots for those who wish to seek them out. Public control of the remaining river bank should be undertaken immediately . . .

"Hemlock Gorge

". . . The area needs refurbishing and some replanting, but it should remain as natural as possible. Continuous pedestrian and bicycle paths along the river should extend through the Gorge to the Upper Falls. A canoe portage path was once available and should be reconstructed. . . .

"Upper Falls

". . . In [some] areas, the river should be opened up, its banks landscaped to permit fairly intensive use by employees in the area as well as residents and visitors. Walkways, playgrounds, playfields, small natural areas, picnic sites and canoe launching sites are recommended.

"Cutler Park

"The marshes known as Cutler Park are the last open, natural area in the lower reaches of the Charles. They are large enough to provide an excellent wildlife habitat, and they should be carefully conserved for flood protection, low flow equalization and nature study. . . . The National Park Service has been successful in developing boardwalks and nature trails for casual nature study. . . . There is an unusual opportunity to develop a canoe nature trail as well, opening up narrow waterways for exploration and again providing interpretive markers.

". . .

"Because of its excellent regional access and central location and natural area development potential, Cutler Park could become one of the most unusual reservations in the entire metropolitan area. For the same reasons it will be subject to pressures to divert portions of the park to other uses. . . .

" Cow Island Pond

". . . Because it will be so readily accessible, intensive recreational facilities are recommended . . . Dredging, widening and ponding of the river is proposed to serve two purposes; flood control and boating. The water quality in this area is expected to be improved to the point where swimming and boating will be possible. The newly enlarged water area would provide space for sailing, canoeing and crew for both individuals and organizations. Although Havey Beach may be rehabilitated for swimming, an indoor Olympic-size pool is also recommended. . . .

". . .

"Dedham Marshes

"The Dedham Marshes are being filled and built up. This development is threatening to block use of the river and is causing a potential flooding problem of some magnitude. . . . Immediate action is needed to prevent further construction on marginal land and further filling of swamps. . . .

"Charles River Village

". . .

"A number of new public access areas, similar in scale to Red Wing Bay are recommended at various upstream sites. In each instance the sites should have easy

> access to the road, provide sufficient parking, and be designed for easy policing and maintenance. . . .
>
> ". . . Protection is the first priority; landscaping and other development should follow as programs and money allow."[13] (Emphasis supplied)

Although this segment is to be upgraded to "B", little primary-contact water activity is expected, primarily because of unfavorable topography. Much of the otherwise swimmable areas are located in marsh and swamp areas. Water skiing is out of consideration because there is relatively little space for safely maneuvering a power boat like that used for skiing, and still less space for safely towing a skier. Effectively, then, this segment of the river is limited to fish and wildlife propagation, fishing, non-power boating, and small power boats.

Besides the water area provided by normal width and length, there are several larger impoundments as noted in the Overview. For comparative purposes, however, an overall total surface area of 400-800 acres is approximated, based on an average width of 100-200 feet.

Since this 400-800 acres occursin a linear form, space requirements of 1/4 to 1/2 miles per canoe apply

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[13] Ibid.

to small power boats. Over the 34 miles, then, between 70 and 140 boats can be accommodated. Essentially no medium or large power boats can be accommodated, however, because of the many obstructions, the inability to traverse long distances (because of the dams), and narrow navigation ways.

In contrast, the surface area of the three Cambridge water supplies is 755± acres and is distributed among three impoundments.

Hobb's Reservoir	558 acres[14]
Stony Brook Reservoir	42 acres
Fresh Pond	155 acres
	755 acres

These ponds can hold 40 power boats, and if water skiing is desired, 40 at a time could be accommodated (assuming 20 acres per boat are required). Alternatively, up to 250 sailboats and small power boats could be accommodated (assuming 3 acres per boat).

Because of the clean, pleasant water bottom typically found at reservoirs, beach areas can readily be created, and, except for Fresh Pond, which might experience shore-space shortages, could support 70,000 swimmers.

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[14] Department of the Army, N.E. Division, Corps of Engineers, Charles River Watershed Study: Water Resources Interim Memo #1; Stony Brook Sub-Watershed, Waltham, Mass., December 1967, p. 25.

The breakdown is as follows: Hobb's, 44,000; Stony Brook, 13,000; and Fresh Pond, 13,000; (on the basis of 1 linear foot of shoreline per person and 8 1/2 miles, 2 1/2,and 2 1/2 miles of shoreline for Hobb's, Stony Brook and Fresh Pond, respectively.)

A study of the Cambridge water supply[15] has made an evaluation of the benefits and costs of abandoning one or all of the water retention areas for recreation uses and concluded its impracticability. For example, use of Hobb's Reservoir for recreation only (uses not specified) would decrease the water available to Cambridge by 25 per cent and would cost about $250,000 annually, plus the cost of diversion around Stony Brook Reservoir. Assigning a value of $3,000 per surface acre for recreation yields annual benefits of $88,000 (annual costs based on 30 year amortization at 3 1/8 per cent interest).

To shift completely to MDC water would cost Cambridge about $1,000,000 annually. On the other hand, approximately 20 million gallons per day now leaving the water course would remain to dilute--and hence upgrade--the Charles River proper, besides the vast recreation resources that would be made available at the three impoundments.

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[15] Ibid.

Perhaps the conclusion that opening the water supply area to extensive recreation activity and turning to the Metropolitan District Commission for supply was made on a base too narrow for a complete overview of area needs. A more complete discussion of the factors which must be considered for a decision on this point is found on pages 123-124.

SEGMENT V

Overview

This segment extends from the Watertown Dam Watertown to the Charles River Dam Boston, a distance of 8.4 miles. Present quality is "C" and "D"; proposed quality is "C". There are approximately 662 acres of water surface in this segment; with the construction of the proposed Warren Avenue Dam, this surface area would be increased 46 acres, to 708. The distribution is shown in Table 16.

There is virtually complete public access along both sides of the river, since it is owned and controlled by the MDC.

Predominant Activity is Boating

The reach of the river from Charles River Dam to Watertown Dam constitutes a protected basin with superlative attractions for oarsmen, sailors and operators of power boats. According to a survey conducted in July

TABLE 16

CHARLES RIVER BASIN ZONES

ZONE	LIMITS	WATER AREA
1	Warren Ave. Dam to Charles River Dam	46 acres
2	Charles River Dam to Longfellow Bridge	65 acres
3	Longfellow Bridge to Harvard Bridge	234 acres
4	Harvard Bridge to Cottage Farm Bridge	134 acres
5	Cottage Farm Bridge to Arsenal St. Bridge	154 acres
6	Arsenal St. Bridge to Watertown Bridge	75 acres
		708 acres

SOURCE: Department of the Army, N.E. Division Corps of Engineers, Charles River Watershed Study: Recreation Interim Memo #2; Recreational Boating Downstream of Moody Street Dam and Other Navigational Data, Waltham, Mass., undated, p. 15.

1967 by the Boston Redevelopment Authority, 803 pleasure boats are permanently berthed in this part of the river. Figure 3 indicates the locations of facilities in this segment.

The following trends were noted:[16]

	Number of Boats, 1959	Number of Boats, 1967	Change
Rowing	302	345	+14%
Sailboats	95	147	+55%
Power Boats	398	311	-28%

The lower end of the Charles River provides remarkable opportunities to enjoy rowing, sailing and cruising in the heart of the city.

Inhibiting Characteristics

Pollution is a cause for concern:

> "Pollution and floating debris are real every-day facts of life in the lower Charles. Two sailing activities have reported that heavy oil residues often cover sailboats' hulls which occasion periodic cleanings. The odor of sewage is also noticeable in many areas. At least two sewage outflows were observed in the Watertown area. Oarsmen have experienced infected blisters through contact with the water.

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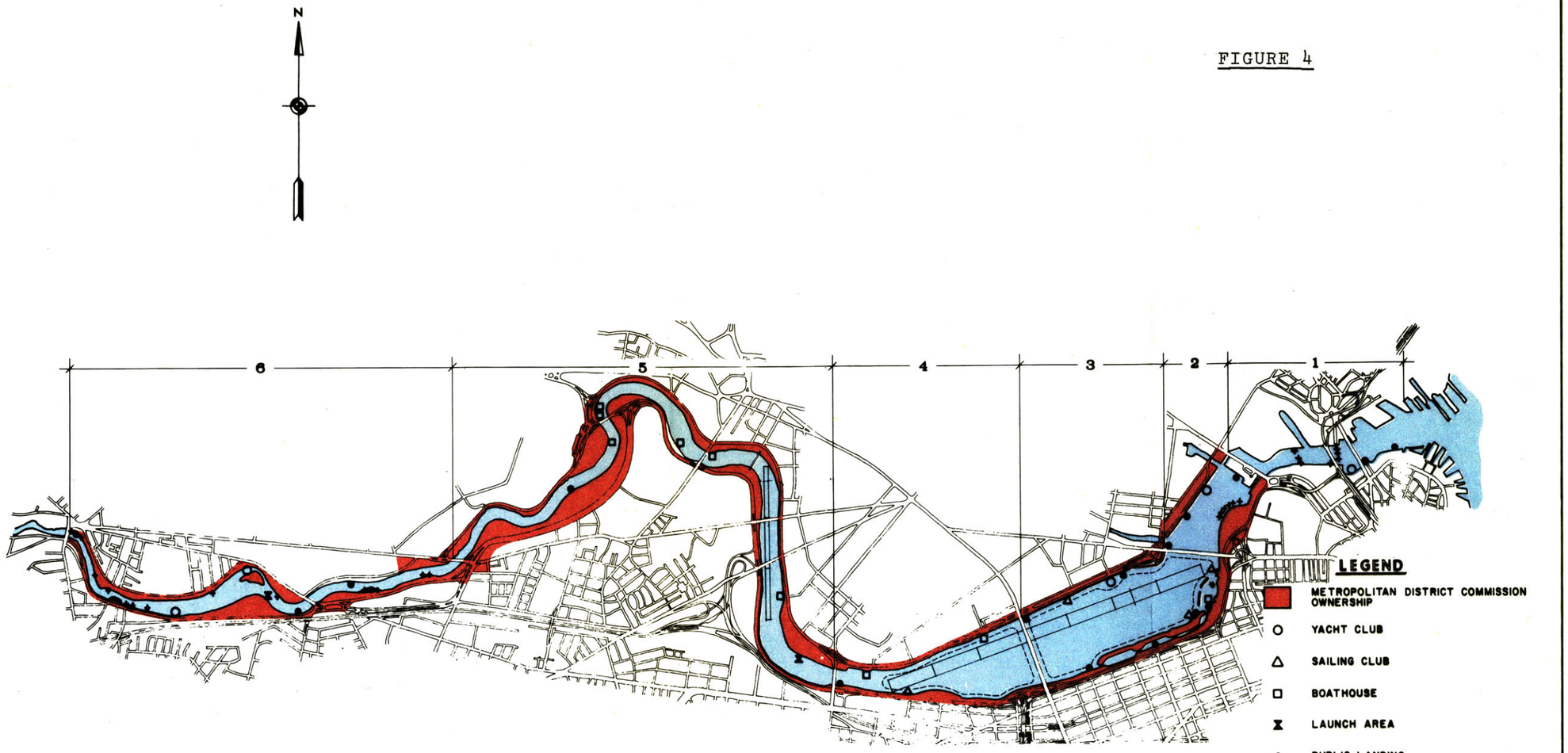
[16] Department of the Army, N.E. Division Corps of Engineers, Charles River Watershed Study: Recreation Interim Memo #2; Recreational Boating Downstream of Moody Street Dam and Other Navigational Data, Waltham, Mass, undated, p. 2.

FIGURE 4



LEGEND

- METROPOLITAN DISTRICT COMMISSION OWNERSHIP
- YACHT CLUB
- SAILING CLUB
- BOATHOUSE
- LAUNCH AREA
- PUBLIC LANDING
- PUBLIC LANDING & EXCURSION BOAT STOP
- SAILING LIMITS
- ROWING RACECOURSE
- FIXED OBSTRUCTION

SCALE IN MILES

0 1/2 1 1½ 2

This Map Courtesy Boston Redevelopment Authority And Adapted By The U.S. Army Corps Of Engineers Waltham, Mass.

CHARLES RIVER STUDY

CHARLES RIVER LOWER BASIN

EXISTING WATER RECREATION

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

> "Floating debris is another hazard. Heavy planks, logs and other assorted pieces of lumber are seen everywhere. Damage to the hulls of shells and sculls, and to propellors is caused by this flotsam and jetsam. In addition, submerged river junk causes damage. Due to the opaque condition of the heavily contaminated water, it is almost impossible to see submerged obstructions before running afoul of them."[17]

The most serious problems are those of space requirements and, to a lesser extent, that of providing adequate storage and launch facilities:

> "Traffic problems and conflicts are inevitable. A crew time trial may be disrupted by the wash of even a small outboard. Shells, one-man sculls, kayaks and sailboats are vulnerable to the washes created by power boats. This problem is aggravated by the location of two yacht clubs in Newton and Watertown, approximately eight miles above the Dam. Since many of the larger power boats cruise outside of the lower basin, they must traverse its length through areas where many sailboats and rowing craft are active. The addition of visiting outboard boats from one area way upstream, and another about 4 miles above the dam adds to the problem. In addition, many of the visitor outboards operate in ignorance of the local zones or areas designated for sailing and rowing.
>
> "The BRA has suggested relocation of some of the boating facilities, and the consolidation of rowing, sailing and yachting facilities, predicated partly on the construction of a new dam and locks at Warren Avenue. In [Table 17],

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[17] Ibid.

the capacities of the various water areas have been estimated. The proposed Warren Avenue Dam would make available a small basin below Charles River Dam in which marina and launching facilities could be installed.

"It seems clear that traffic problems in the existing lower river will continue to grow, as increasing numbers of boats utilize this rather limited water area. . . ."[18]

"There is very real concern for the ultimate density of use of the Charles Basin in the light of anticipated demands and the size of the water area. The Basin is the most prestigious boating area near Boston. It has better public facilities than those in Boston Harbor and is convenient for many organizations. The existing users have boated for years with minimum conflict and a general spirit of cooperation. The success of these users is ironically responsible for the increasing popularity of the area. The Basin has reached the point where a review of the problems and policies for future use is essential.

"In 1964 the MDC convened [a committee of public, institutional, and private users of the Basin met to discuss their common problems and to explore possible solutions.]

"- the control of power boat wake
- the location of new launching sites for power boats to minimize conflicts with other uses
- minimizing conflicts between rowing courses and other uses
- the growing college sailing demand and possible inter-college programs
- identification and control of accident sources

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[18] Ibid.

> "It also took note of a study by Charles W. Eliot II for the MDC that identified twenty organizations and more than fifteen hundred boats on the river. 'The number of shells, canoes, sailboats and motorboats of all kinds has increased enormously in recent years with inevitable problems of conflicting use, inadequacy of facilities and procedures for regulations. . . .' New regulations and development of alternative or supplementary facilities in other parts of the metropolitan area will be necessary to prevent impossible over-crowding and unpleasant conditions in the Basin."[19]

That water quality improvement is not of highest priority is clearly evident from the fact that much boating does occur here in spite of poor water quality. This unique resource conveniently located in the heart of the metropolitan area is subjected to such a large demand that the quality considered suitable to the users decreases. This is not to say that the quality of the boating experience would not be greatly increased through water quality improvements. Although there are indications that the Basin would be used to capacity without water quality improvements, those using it in its present condition are subject to health hazards and objectionable aesthetic reactions.

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[19] Metropolitan Area Planning Council, The Mystic, Charles and Neponset Rivers, Preliminary draft, undated, pp. 33-34.

TABLE 17

CHARLES RIVER BASIN BOATING ZONES AND CAPACITIES

Zone	1967 Boat Totals, Priority Types	Unused Boating Capacity*	Remarks	1967 Boat Totals All Types	Proposed Totals All Types
1	-(PB)	300 small boats	After improvements: 200 small boats proposed	---	200
2	60(PB)	190 Yachts	With relocated 100 boats from Newton and Watertown Yacht Clubs there will be room for 90 additional yachts	60	250
3	129(S)	---	Presently sailing at capacity	249	249
4	9(S)	65 Sailboats	70 Sailboat pavilion proposed at Deerfield, West of Charlesgate	61	122

TABLE 17, continued

Zone	1967 Boat Totals, Priority Types	Unused Boating Capacity*	Remarks	1967 Boat Totals All Types	Proposed Totals All Types
5	200(R)	40 Rowing	40-boat boathouse proposed at Sherborn, B. U. Shore	221	261
6	100(PB)	120 Rowing	3 40-boat boathouses proposed; relocation of yacht clubs	212	120
		715 Boats		803	1202

*Capacity calculated for:
Yachts: on basis of 10 yachts/acre berths and 25 acre allocated ship area
Sailboats: on basis of 129 sailboats in 234 acres water of Zone 3
Rowing: on basis of 200 boats (+20% increase following relocation of yachts and outboards) in 154 acres of Zone 5
Small-boat Marina: on basis of 75 small boats/acre

Note: Description of Zones on page 109.

SOURCE: Department of the Army, N.E. Division Corps of Engineers, Charles River Watershed Study: Recreation Interim Memo #2; Recreational Boating Downstream of Moody Street Dam and Other Navigational Data, Waltham, Mass., undated, pp. 16, 17.

Evaluation

Present activities and their trends indicate that there exists a strong demand for boating activity on this segment. This demand is so strong as to fully utilize the surface area here.

Although the classification is for "C" quality, there has been, and still is, a desire by some to raise this to "B" quality (hearings on Coastal Waters Classification) so as to permit swimming and perhaps water skiing.

Water skiing requires a minimum surface area of 5 acres per boat, while power boating requires about 3 acres per boat, and sailing might require 1 acre per boat. The larger requirements for water skiing are caused by safety factors and the need for considerable maneuverability. To consider water skiing, then, would mean that only about half as many persons could be accommodated than if only boating were encouraged.

Swimming, on the other hand, is a space-intensive activity and many more persons can be accommodated per water area in this activity than for either water skiing or boating. Allowing 150 square feet of surface area per swimmer yields nearly 300 swimmers per acre of water surface. Setting off a 100-foot wide swimming area clearly (and physically) separating boat traffic from the area, would allow 1 1/2 linear feet of shore per

person. For every 300 swimmers accommodated, the boating capacity would be reduced by one (sailboats or canoes). In fact, one mile of beach, pre-empting 12.1 water-acres, would displace only 12 sailboats or canoes, 4 power boats, or 3 water skiing parties. At the most, then, 24 persons might be displaced, but 3,600 swimmers might be accommodated (assuming that capacity for 50 people at one time is adequate for 1000 population, a swimming area of this size serves a population of 72,000).[20]

Assuming that the water-bottom characteristics are suitable, the limitations most urgent are those dealing with land adjacent to the water. At 150 square feet per swimmer, the same amount of sunbathing area is required as water area.

Half again as much land is required for utilities, picnicking and related activities. And, parking requirements of 300 square feet per car would increase the total land requirement by 150 square feet for each person (2 persons per car) arriving by auto. Per person space requirements, then, are approximately:

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[20] California Public Outdoor Recreation Plan Committee, California Public Outdoor Recreation Plan, Sacramento, Calif. 1960, pp. 48-84.

water area		150 sq. ft.
beach	150 sq. ft.	
utilities, etc.	75 sq. ft.	
land area, w/o parking		225 sq. ft.
parking for auto arrivals		150 sq. ft.
land area, with parking		375 sq. ft.

Potential swimming areas, then, are restricted to places along the Basin where the supporting land area is adequate (and safe). A more complete discussion of the factors which must be considered for a decision on this point is found on pages 123-124.

CONCLUSION

The alternatives considered in the Case Study are not meant to be concise recommendations as to the classifications which should be imposed on the various segments, nor are they concise recommendations as to selecting areas for accommodating recreation activities. But they do illustrate that in order to provide for a specific recreation or conservation activity, it is often virtually meaningless to concentrate on water quality alone to the neglect of space, access, and associated land characteristics which in some cases may be far more important than water quality, but in any case should always receive equal consideration with it.

The Case Study has indicated the manner in which quality, quantity, access, and related land pre-requisites of recreation and conservation activities determine first which activities are possible, and then their levels of intensity.

For the Charles River the primary benefits of the present water quality classification are those of fish and wildlife propagation and hence fishing. The problems of access are minimized because of relatively extensive public holdings along the river, especially in Segment V, and because of the relative navigability of

most sections for non-power boating and small power boats. For power boating or general navigation along extensive lengths of the river, the many dams prevent much of any use. Further, the relatively narrow widths limit the amount of boating possible, especially above the Basin.

Finally, the dominant character of the adjacent marsh and swamps and the muddy (and sludgy) river bottom greatly restrict activities like swimming throughout much of Segments III and IV.

But, if the parameters describing the size of the water area, the character of the adjacent land and water bottom and access to it are considered variables subject to the same attention as water quality, the potential of a water area can change markedly.

Segment III can presently accommodate 60 canoes and small power boats along its length (on the basis of 1/2 mile of stream per craft), and its three impoundments can accommodate 90 power boats. Yet, in the event of substantial construction of retention areas for flood control and water quality improvement, the capacity at impoundments might change drastically. But if the water quality here were increased to allow primary-contact activities, up to 35,000 swimmers or 15 water skiers might be accommodated at the three existing impoundments alone.

Segment IV can accommodate 70-140 canoes and small power boats but very few larger craft and sailboats because of the many dams preventing long trips, and the frequently narrow travel way.

Furthermore, both Segments III and IV have unique value as conservation areas. To extensively modify the natural topography would greatly diminish these conservation values.

Swimming might be a possible activity, but because its shore, water bottom, and access requirements are so different from those characteristics of much of this segment, the provision of swimming activity might greatly conflict with fish and wildlife propagation and conservation objectives in general.

Segment V, if water quality is improved sufficiently, might be able to accommodate considerable swimming activity. If such would be the desire, restrictions posed by a shortage of adjacent land for ancillary activities would have to be obviated.

If this rather wide range of possibility exists when all parameters can be controlled, water quality should not be treated as the only variable. For if the primary objective of a water quality improvement program is for society to realize increased benefits from its water resources (see pp. 7-10) then all parameters bearing on the benefits are important.

For all of the situations presented in the Case Study, the choice between swimming, boating and other possible activities would depend on several considerations. The demand for the various uses of a region's water resources is an important factor. For example, the demand for swimming facilities may not be great in Segment III but high in Segment V.

Another important consideration is whether particular water areas are unique or scarce in a region or there are several possible alternative sites for a particular activity. For example, Segment III in its present state is a particularly valuable fish and wildlife propagation area and considered by some as highly worthy of conservation. Another example is the potential swimming capacity of Segment V, should its water quality be raised to a "B" level. Up to 300 swimmers might be accommodated at a loss of about 24 boaters (12 boats at 2 persons per boat), but other considerations could have an important effect on a decision. There would be the extent of the commitment of the Metropolitan District Commission for extensive artificial swimming facilities and the difficulty, if not impossibility, of providing artificial boating facilities in this area.

Finally, the consideration of alternative costs is an important factor. For example, the use of the present

Cambridge water supplies for recreation activities might not be a proposal as impractical as had been concluded, if compensatory costs to Cambridge were to be paid by some type of reimbursement scheme, with revenues derived from user charges and/or funds which otherwise might have to be spent in providing alternative facilities. Another example is the costs involved in raising the water quality in Segment V to a "B" level. They might exceed the costs of providing artificial areas for the same number of people.

That the set of space, quality, access, and associated land characteristics can interact in innumerable combinations as to be favorable to either one or more specific activities does not alone clarify a classification schema. But the first point evident from this is that it may not be productive to require a minimum level of treatment in all cases.

It is possible--indeed, in some cases probable--that the parameters which must be considered most fixed in that they are determined through exogenous considerations such as flood control, are physical. That is, a set of physical characteristics other than quality would create the context in which the decisions regarding activities must be made. Frequent impoundments, for instance, may raise possibilities of swimming areas

requiring a certain level of quality, whereas another set of constraints may essentially eliminate primary contact activities. But since the present approach is to require an initial minimum level of treatment (see pp. 10 -11), the water quality would be raised to a level arbitrary with respect to sister parameters of quantity and access.

The other point is that a universally accepted frame of reference is essential in putting all the parameters in perspective. The frame of reference should be the needs of society for water-based recreation activities and conservation uses (see pp. 10-11). For Massachusetts, a logical starting point is the Massachusetts Outdoor Recreation Plan 1966. From this, one can obtain an indication of those activities most desired and needed. These can be compared against the total resources available for their fulfillment.

For example, if there is a need for primary water-contact activities like swimming or water-skiing, those water areas potentially able to contribute to the need can be located. The modification of those characteristics necessary to supply the activity can then be compared as to cost or any other decision variables. Table 18 gives a summary of the primary recreation needs of Region V. Region V is one of seven geographical areas

TABLE 18

THE BOSTON AREA: PRIMARY RECREATION NEEDS

Activity	Total Demand 1970	Available Public Supply 1965	Recommended Additions 1970	Supply 1970	Public Supply Total Demand Per cent 1970
Swimming (Persons)	49,000	21,400*	12,400	33,800	69 %
Camping (Campsites)	1,800	80	150	230	13
Fishing (Persons)	55,000	17,700+	Balance	55,000	100
Picnicking (Picnic Sites)	5,600	1,400	2,420	3,820	68
Boating (Boats)	16,100	600	1,700	2,300	14

*Includes 11,300 transferred from Region IV excess coastal supply.

SOURCE: Edwards & Kelcey, Massachusetts Outdoor Recreation Plan 1966, Massachusetts Department of Natural Resources, 1966, p. 51.

into which the state had been subdivided in the Outdoor
(See map on page 26.)
Recreation study./ It essentially consists of the Boston and Brockton Metropolitan Areas. Depending on analysis of more detailed studies, it may be found that for some water areas the point of diminishing returns as regards the enhancement of water-based recreation and conservation needs occurs at a "C" level, while for other areas raising to a "B" level may be most effective.

More important, it may become evident that ignoring water quality improvement in favor of other parameters may be the most productive approach. The discussion of the potential Cambridge water supply areas as an alternative to that of Segment IV was included to illustrate (and only to illustrate) the myriad possibilities which might become feasible.

As it stands presently, the Massachusetts Outdoor Recreation Plan 1966 does mention acquisition as a formidable and increasingly difficult problem. Reference in this paper has already been made to the constant loss of land slated for acquisition (see p.25). Further, it covers the problem of land acquisition as it discusses Region V.

> "Major land acquisitions are difficult in the region because competition from other uses (industrial, commercial and residential) makes land cost prohibitively high. However, many large areas

> have been bypassed in the process of suburban sprawl. These areas--the swamps, the marshes and the dumps--may be the region's most valuable land asset. Surrounded by high density residential developments, many people have ready access to them. With patience, these areas can be developed into wooded parks and charming recreation spaces."[1]

In attempting to meet these needs, the following recommendations are made:

> "To help meet the demand for swimming, it is recommended that a major ocean beach and high density swimming pools be provided by 1970. Full development of the inland ponds to aid in meeting the fishing demand is further recommended. Picnicking should be developed primarily to compliment other activities. To satisfy the boating demand it is recommended that the coastal areas be given greater emphasis than the inland ponds."[2]

With a fully-coordinated recreation/conservation program having as its goal the provision of these needs rather than the imposition of equity standards for treatment, some of these recommendations might possibly be drastically altered.

That the emphasis placed on equity considerations at this time is possibly doing more harm to an overall

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[1] Edwards & Kelcey, Massachusetts Outdoor Recreation Plan 1966, Massachusetts Department of Natural Resources, 1966, pp. 50-51.

[2] Ibid.

recreation program than good is made clear when one realizes that any society with limited resources of necessity must reduce its efforts in some areas if effort is expended on a new, related function. In this case, society will tend to reduce its efforts in, say, land acquisition or public access facilities if it embarks on a new program essentially related to these existing programs--that new program being water pollution control. If this generality lacks a clear proof it nevertheless can be adapted as an alternative to the imposition of a minimum level of pollution treatment.

The resources which would otherwise be spent on treatment facilities could take the form of a levy on those polluters in cases where, even with treatment, the benefits to society are minimal. (There is a weak analogy of this proposal to that made by Kneese[3] but it differs from his in extremely important ways. Most important, this proposal is not economic in that the levy is not based on activities foregone but on treatment facilities costs not spent.) The charges would be made in lieu of treatment facilities at the discretion of the

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[3]Allen V. Kneese, The Economics of Regional Water Quality Management, Baltimore: The Johns Hopkins Press, 1964.

recreation/conservation agency responsible for provision of these activities when more would be gained through spending these resources on other programs, e.g., land acquisition, dam construction (or removal), access facilities, and so forth.

Once the interdependence of the parameters is established, and society realizes the need to have full influence over all of them, it will be possible to adopt more comprehensive controls over water areas (and natural resources in general). In time it might even be possible to regulate the location of pollution sources altogether and to establish not only basin-wide water quality zoning, but also basin-wide land-use zoning.

At the least, it is clear that it is necessary--indeed, critical---to modify the procedure by which water quality classifications are set. At the Federal level, a positive approach does exist and could be a viable one in serving as a guideline for setting water quality classifications. What is needed is a switch in emphasis from that of requiring uniform treatment of effluent to that of basing the classification on those activities needed by society.

At the state level--Massachusetts in particular--considerably more sophistication is desperately needed in setting classifications. There is a need for substantial improvements in the planning machinery within

state government, especially in the field of recreation planning and in plan implementation. The inclusion of water quality in the arsenal of manipulable parameters can both strengthen the recreation planning process and provide a sound basis for setting water quality classifications.

APPENDIX I

COMMONWEALTH OF MASSACHUSETTS

WATER RESOURCES COMMISSION

DIVISION OF WATER POLLUTION CONTROL

WATER QUALITY STANDARDS

Adopted by the Massachusetts Division of Water Pollution Control on March 3, 1967, in accordance with the Provisions of Section 27 (4) of Chapter 21 of the General Laws, and in accordance with the procedure required by Chapter 30A of the General Laws, and after a public hearing held on February 17, 1967

Filed with Secretary
of State On
March 6, 1967

15M 3-67-944710 Estimated Cost Per Book .115

Standards of Water Quality

I-2

1. General - To achieve the objectives of the Massachusetts Clean Water Act and to assure best use of the waters of the Commonwealth, the following standards are adopted and shall be applicable to all waters of the Commonwealth or to different segments of the same waters. The Classes shall be assigned by the Division of Water Pollution Control.

In the classification of waters due consideration will be given to all factors involved including public health, public enjoyment, propagation and protection of fish and wildlife, and economic and social development. Classifications are not intended to permit indiscriminate waste disposal or to allow minimum efforts of waste treatment under any circumstance.

When an effluent is permitted to be discharged to the receiving waters, cognizance shall be given both in time and distance to allow for mixing of effluent and stream. Such distances required for complete mixing shall not affect the water usage Class adopted.

Recommendations on other waste parameters will constitute a portion of the continuing effort of the Division as improved standard methods are developed or revisions consistent with the enhancement of the waters of the Commonwealth are justified.

Water quality parameters not specifically denoted shall not exceed the recommended limits on the most sensitive and governing water class use. In areas where fisheries are the governing consideration and approved limits have not been established, bio-assays shall be performed as required by the appropriate agencies.

Standards of Water Quality

I-3

Fresh Waters

Class A - Waters designated for use as public water supplies in accordance with Chapter 111 of the General Laws. Character uniformly excellent.

Standards of Quality

Item	Water Quality Criteria
1. Dissolved oxygen	Not less than 75% of saturation during at least 16 hours of any 24-hour period and not less than 5 mg/l at any time.
2. Sludge deposits-solid refuse-floating solids-oil-grease-scum	None allowable
3. Color and turbidity	None other than of natural origin
4. Coliform bacteria per 100 ml.	Not to exceed an average value of 50 during any monthly sampling period.
5. Taste and odor	None other than of natural origin
6. pH	As naturally occurs
7. Allowable temperature increase	None other than of natural origin
8. Chemical constituents	None in concentrations or combinations which would be harmful or offensive to humans, or harmful to animal, or aquatic life.
9. Radioactivity	None other than that occurring from natural phenomena

Class B - Suitable for bathing and recreational purposes including water contact sports. Acceptable for public water supply with appropriate treatment. Suitable for agricultural, and certain industrial cooling and process uses; excellent fish and wildlife habitat; excellent aesthetic value.

Standards of Quality

Item	Water Quality Criteria
1. Dissolved oxygen	Not less than 75% of saturation during at least 16 hours of any 24-hour period and not less than 5 mg/l at any time.
2. Sludge deposits-solid refuse-floating solids-oils-grease-scum	None Allowable
3. Color and turbidity	None in such concentrations that would impair any usages specifically assigned to this class.
4. Coliform bacteria per 100 ml	Not to exceed an average value of 1000 during any monthly sampling period nor 2400 in more than 20% of samples examined during such period.
5. Taste and odor	None in such concentrations that would impair any usages specifically assigned to this class and none that would cause taste and odor in edible fish.
6. pH	6.5 - 8.0
7. Allowable temperature increase	None except where the increase will not exceed the recommended limit on the most sensitive receiving water use and in no case exceed 83° F in warm water fisheries, and 68° F in cold water fisheries, or in any case raise the normal temperature of the receiving water more than 4° F.

8. Chemical constituents	None in concentrations or combinations which would be harmful or offensive to human, or harmful to animal or aquatic life or any water use specifically assigned to this class.
9. Radioactivity	None in concentrations or combinations which would be harmful to human, animal, or aquatic life for the appropriate water use. None in such concentrations which would result in radio-nuclide concentrations in aquatic life which exceed the recommended limits for consumption by humans.
10. Total phosphate	Not to exceed an average of 0.05 mg/1 as P during any monthly sampling period.
11. Ammonia	Not to exceed an average of 0.5 mg/1 as N during any monthly sampling period.
12. Phenols	Shall not exceed .001 mg/1 at any time.

Class C - Suitable for recreational boating; habitat for wildlife and common food and game fishes indigenous to the region; certain industrial cooling and process uses; under some conditions acceptable for public water supply with appropriate treatment. Suitable for irrigation of crops used for consumption after cooking. Good aesthetic value.

Standards of Quality

Item	Water Quality Criteria
1. Dissolved oxygen	Not less than 5 mg/1 during at least 16 hours of any 24-hour period nor less than 3 mg/1 at any time. For seasonal cold water fisheries at least 5 mg/1 must be maintained.
2. Sludge deposits-solid-refuse floating solids-oils-grease-scum	None allowable except those amounts that may result from the discharge from waste treatment facilities providing appropriate treatment.

3. Color and turbidity	None allowable in such concentrations that would impair any usages specifically assigned to this class.
4. Coliform bacteria	None in such concentrations that would impair any usages specifically assigned to this class.
5. Taste and odor	None in such concentrations that would impair any usages specifically assigned to this class, and none that would cause taste and odor to edible fish.
6. pH	6.0 - 8.5
7. Allowable temperature increase	None except where the increase will not exceed the recommended limits on the most sensitive receiving water use and in no case exceed 83° F in warm water fisheries, and 68° F in cold water fisheries, or in any case raise the normal temperature of the receiving water more than 4° F.
8. Chemical constituents	None in concentrations or combinations which would be harmful or offensive to human, or harmful to animal or aquatic life or any water use specifically assigned to this class.
9. Radioactivity	None in concentrations or combinations which would be harmful to human, animal, or aquatic life for the appropriate water use. None in such concentrations which would result in radio-nuclide concentrations in aquatic life which exceed the recommended limits for consumption by humans.
10. Total phosphate	Not to exceed an average of 0.05 mg/l as P during any monthly sampling period.

11. **Ammonia**	**Not to exceed an average of 1.0 mg/l as N during any monthly sampling period.**
12. **Phenols**	**Not to exceed an average of 0.002 mg/l at any time.**

Class D - Suitable for aesthetic enjoyment, power, navigation, and certain industrial cooling and process uses. Class D waters will be assigned only where a higher water use class cannot be attained after all appropriate waste treatment methods are utilized.

Item	Specifications
1. Dissolved oxygen	Not less than 2 mg/l at any time.
2. Sludge deposits - solid refuse-floating solids-oils-grease-scum	None allowable except those amounts that may result from the discharge from waste treatment facilities providing appropriate treatment.
3. Color and turbidity	None in such concentrations that would impair any usages specifically assigned to this class.
4. Coliform bacteria	None in such concentrations that would impair any usages specifically assigned to this class.
5. Taste and odor	None in such concentrations that would impair any usages specifically assigned to this class.
6. pH	6.0 - 9.0
7. Allowable temperature increase	None except where the increase will not exceed the recommended limits on the most sensitive receiving water use and in no case exceed 90° F.
8. Chemical constituents	None in concentrations or combinations which would be harmful to human, animal, or aquatic life for the designated water use.

9. Radioactivity	None in such concentrations or combinations which would be harmful to human, animal, or aquatic life for the designated water use. None in such concentrations which will result in radio-nuclide concentrations in aquatic life which exceed the recommended limits for consumption by humans.

Notes:

1. All wastes shall receive appropriate waste treatment which is defined as secondary treatment with disinfection or its industrial waste treatment equivalent except when a higher degree of treatment is required to meet the objectives of the water quality standards, all as determined by the Division of Water Pollution Control. Disinfection from October 1 to May 1 may be discontinued at the discretion of the Division of Water Pollution Control.

2. Appropriate water supply treatment is as determined by the Massachusetts Department of Public Health.

3. These water quality standards do not apply to conditions brought about by natural causes.

4. Class B, & C waters shall be substantially free of pollutants that will:

   (1) unduly affect the composition of bottom fauna

   (2) unduly affect the physical or chemical nature of the bottom

   (3) interfere with the spawning of fish or their eggs

5. The average minimum consecutive 7 day flow to be expected once in ten years shall be used in the interpretation of the standards except where noted.

6. The amount of disinfection required shall be equivalent to a free and combined chlorine residual of at least 1.0 mg/l after 15 minutes contact time during peak hourly flow or maximum rate of pumpage.

Coastal and Marine Waters

Class SA - Suitable for any high quality water use including bathing and water contact sports. Suitable for approved shellfish areas.

Standards of Quality

Item	Water Quality Criteria
1. Dissolved oxygen	Not less than 6.5 mg/l at any time.
2. Sludge deposits-solid refuse-floating solids-oil-grease-scum	None allowable
3. Color and turbidity	None in such concentrations that will impair any usages specifically assigned to this class.
4. Coliform bacteria per 100 ml	Not to exceed a median value of 70 and not more than 10% of the samples shall ordinarily exceed 230 during any monthly sampling period.
5. Taste and odor	None allowable
6. pH	6.8 - 8.5
7. Allowable temperature increase	None except where the increase will not exceed the recommended limits on the most sensitive water use.
8. Chemical constituents	None in concentrations or combinations which would be harmful to human, animal, or aquatic life or which would make the waters unsafe or unsuitable for fish or shellfish or their propagation, impair the palatability of same, or impair the waters for any other uses.

9. Radioactivity	None in concentrations or combinations which would be harmful to human, animal, or aquatic life for the designated water use. None in such concentrations which would result in radio-nuclide concentrations in aquatic life which exceed the recommended limits for consumption by humans.
10. Total phosphate	Not to exceed an average of 0.07 mg/l as P during any monthly sampling period.
11. Ammonia	Not to exceed an average of 0.2 mg/l as N during any monthly sampling period.

Class SB - Suitable for bathing and recreational purposes including water contact sports; industrial cooling; excellent fish habitat; good aesthetic value; and suitable for certain shellfisheries with depuration. (Restricted Shellfish Areas).

Standards of Quality

Item	Water Quality Criteria
1. Dissolved oxygen	Not less than 5.0 mg/l at any time.
2. Sludge deposits-solid refuse-floating solids-oils-grease-scum	None allowable
3. Color and turbidity	None in such concentrations that would impair any usages specifically assigned to this class.
4. Coliform bacteria per 100 ml	Not to exceed a median value of 700 and not more than 2300 in more than 10% of the samples during any monthly sampling period.
5. Taste and odor	None in such concentrations that would impair any usages specifically assigned to this class and none that would cause taste and odor in edible fish or shellfish.
6. pH	6.8 - 8.5

7. Allowable temperature increase	None except where the increase will not exceed the recommended limits on the most sensitive water use.
8. Chemical constituents	None in concentrations or combinations which would be harmful to human, animal or aquatic life or which would make the waters unsafe or unsuitable for fish or shellfish or their propagation, impair the palatability of same, or impair the water for any other usage.
9. Radioactivity	None in concentrations or combinations which would be harmful to human, animal, or aquatic life for the appropriate water use. None in such concentrations which would result in radio-nuclide concentrations in aquatic life which exceed the recommended limits for consumption by humans.
10. Total phosphate	Not to exceed an average of 0.07 mg/l as P during any monthly sampling period.
11. Ammonia	Not to exceed an average of 0.2 mg/l as N during any monthly sampling period.

Class SC - Suitable for aesthetic enjoyment; for recreational boating; habitat for wildlife and common food and game fishes indigenous to the region; industrial cooling and process uses.

Standards of Quality

Item	Water Quality Criteria
1. Dissolved oxygen	Not less than 5 mg/l during at least 16 hours of any 24-hour period nor less than 3 mg/l at any time.

2. Sludge deposits-solid refuse-floating solids-oils-grease-scum	None except that amount that may result from the discharge from a waste treatment facility providing appropriate treatment.
3. Color and turbidity	None in such concentrations that would impair any usages specifically assigned to this class.
4. Coliform bacteria	None in such concentrations that would impair any usages specifically assigned to this class.
5. Taste and odor	None in such concentrations that would impair any usages specifically assigned to this class and none that would cause taste and odor in edible fish or shellfish.
6. pH	6.5 - 8.5
7. Allowable temperature increase	None except where the increase will not exceed the recommended limits on the most sensitive water use.
8. Chemical constituents	None in concentrations or combinations which would be harmful to human, animal or aquatic life or which would make the waters unsafe or unsuitable for fish or shellfish or their propagation, impair the palatability of same, or impair the water for any other usage.
9. Radioactivity	None in such concentrations which would be harmful to human, animal or aquatic life for the designated water use. None in such concentrations which would result in radio-nuclide concentrations in aquatic life which exceed the recommended limits for consumption by humans.

10. Total phosphate	Not to exceed an average of 0.07 mg/l as P during any monthly sampling period.
11. Ammonia	Not to exceed an average of 1.0 mg/l as N during any monthly sampling period.

Notes:

1. Coastal and marine waters are those subject to the rise and fall of the tide.

2. Appropriate treatment is defined as the degree of treatment with disinfection required for the receiving waters to meet their assigned state or interstate classification and to meet the objectives of the water quality standards. Disinfection from October 1 to May 1 may be discontinued at the discretion of the Division of Water Pollution Control.

3. The water quality standards do not apply to conditions brought about by natural causes.

4. The waters shall be substantially free of pollutants that will:

   (1) unduly affect the composition of bottom fauna

   (2) unduly affect the physical or chemical nature of the bottom

   (3) interfere with the spawning of fish or their eggs

5. The standards shall apply at all times in coastal and marine waters

6. The amount of disinfection required shall be equivalent to a free and combined chlorine residual of at least 1.0 mg/l after 15 minutes contact time during peak hourly flow or maximum rate of pumpage.

Approved by Commissioner of Public Health

Date: 3/3/67

Dr. Alfred L. Frechette

Approved by Division of Water Pollution Control

Date: 3/3/67

Thomas C. McMahon
Director

A TRUE COPY ATTEST:

APPENDIX II

QUESTIONNAIRE SENT TO CONSERVATION COMMISSIONS OF MUNICIPALITIES BORDERING ON THE CHARLES RIVER, ABOUT MARCH 20, 1968, INCLUDING RECIPIENTS AND RESPONDENTS.

DATA SHEET page 1.

1. City or Town of _____.

2. According to the Mass. Water Resources Commission, the present water quality of the Charles as it flows through this municipality is _____. (Accompanying sheet explains classification. Accompanying map shows stretch in question.)

What are the present recreation and conservation uses of this stretch of the Charles?

activity	No	IF YES, RELATIVE INTENSITY Heavy	Medium	Light
Fishing:	____	_____	_____	_____
Boating:				
canoeing, rowing	____	_____	_____	_____
power boating	____	_____	_____	_____
Water-contact sports:				
swimming.	____	_____	_____	_____
water-skiing.	____	_____	_____	_____
Is this stretch of the Charles serving as a breeding ground and/or shelter for fish and wildlife:	____	_____	_____	_____

Please describe briefly special areas or facilities, if any, giving rise to these activities.

3. In general, the uses possible with this quality of water are as shown on the attached sheet. How do the actual uses compare to the general uses? Would you comment on any differences.

4. (This question is similar to question #2, with the important exception that it now considers uses possible with the present water quality.) (note: The score on each item of this question should not be lower than the corresponding items of question #2.)

activity	No	IF YES, RELATIVE INTENSITY Heavy	Medium	Light
Fishing:	____	_____	_____	_____
Boating:				
canoeing, rowing	____	_____	_____	_____
power boating	____	_____	_____	_____

(continued on next page.)

DATA SHEET page 2.

4. (continued from page 1.)

activity	No	IF YES, RELATIVE INTENSITY Heavy	Medium	Light
Water-contact sports:				
swimming.	____	_____	_____	_____
water-skiing.	____	_____	_____	_____
Is this stretch of the Charles capable of serving as a breeding ground and/or shelter for fish and wildlife:	____	_____	_____	_____

Please describe briefly special areas or facilities, if any, over and above those of question #2, which would make these uses possible.

5. Would you comment on any differences between the answers to questions #2 and #4?

6. The proposed future quality of water in this stretch of the Charles is given by the Mass. Water Resources Commission to be _____. In general, possible uses of water of this quality are given on the attached sheet. What would you consider the uses possible in this stretch of the Charles, given that the quality of water does become ____?

activity	No	IF YES, RELATIVE INTENSITY Heavy	Medium	Light
Fishing:	____	_____	_____	_____
Boating:				
canoeing, rowing	____	_____	_____	_____
power boating	____	_____	_____	_____
Water-contact sports:				
swimming.	____	_____	_____	_____
water-skiing.	____	_____	_____	_____
Is this stretch of the Charles capable of serving as a breeding ground and/or shelter for fish and wildlife:	____	_____	_____	_____

(continued on next page.)

DATA SHEET page 3.

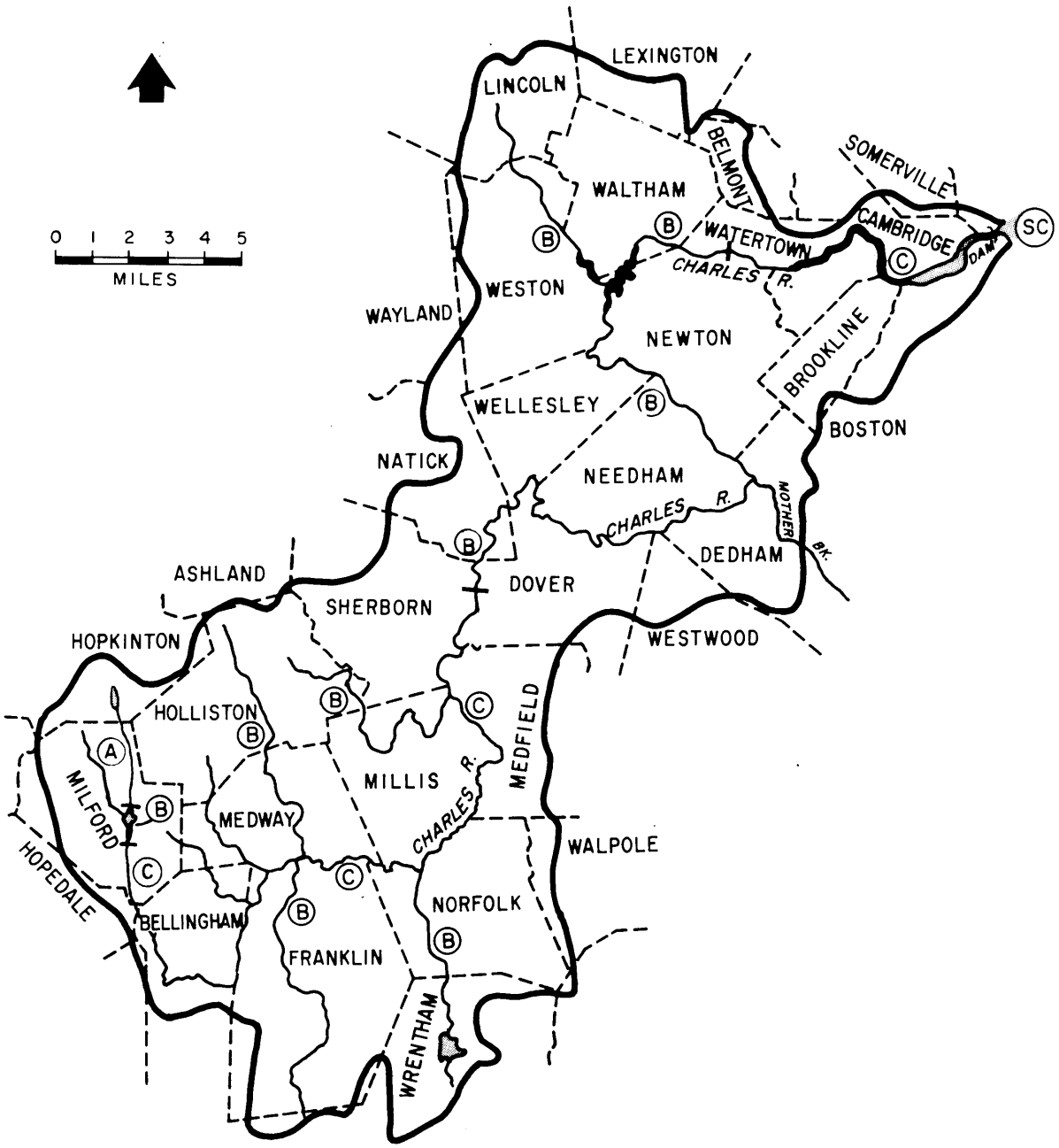
6. (continued from page 2.)
Please describe briefly special areas or facilities, if any, over and above those of question #2, which would make these uses possible.

7. Would you comment on any differences between the answers to questions #6 and #4, and differences between questions #6 and #2.

8. In your opinion is there a Town-wide consensus regarding the proposed water quality standards?

No..... _____ strong disagreement
_____ apathy

Yes..... _____ standards should be higher
_____ standards set are about right
_____ standards should be lower
_____ there should be no standards



COMMONWEALTH OF MASSACHUSETTS
WATER RESOURCES COMMISSION

CHARLES RIVER BASIN

CLASSIFICATION

WATER USE CLASSES - (A) (B) (C) (D) (SB)

— CHANGE CLASSIFICATION

COMMONWEALTH OF MASSACHUSETTS
WATER RESOURCES COMMISSION
DIVISION OF WATER POLLUTION CONTROL

WATER QUALITY STANDARDS

Class A	Waters designated for use as public water supplies in accordance with Chapter 111 of the General Laws. Character uniformly excellent.
Class B	Suitable for bathing and recreational purposes including water contact sports. Acceptable for public water supply with appropriate treatment. Suitable for agricultural, and certain industrial cooling and process uses; excellent fish and wildlife habitat; excellent aesthetic value.
Class C	Suitable for recreational boating; habitat for wildlife and common food and game fishes indigenous to the region; certain industrial cooling and process uses; under some conditions acceptable for public water supply with appropriate treatment. Suitable for irrigation of crops used for consumption after cooking. Good aesthetic value.
Class D	Suitable for aesthetic enjoyment, power, navigation, and certain industrial cooling and process uses. Class D waters will be assigned only where a higher water use class cannot be attained after all appropriate waste treatment methods are utilized.

QUESTIONNAIRE RECIPIENTS AND RESPONDENTS

*Milford
*Hopedale
Mendon
Bellingham
Franklin
*Medway
*Norfolk
Millis
*Medfield
*Sherborn
*Dover
Natick
Wellesley
*Needham
Westwood
Dedham
Newton
*Weston
*Waltham
*Watertown

*Indicates Respondents

APPENDIX III

TABLE GIVING ESTIMATED FISH AND WILDLIFE RECREATION ON CHARLES RIVER, AS RECEIVED FROM PAUL S. MUGFORD, STATE ORNITHOLOGIST, MASSACHUSETTS DIVISION OF FISHERIES AND GAME, APRIL 15, 1968.

The Commonwealth of Massachusetts
Division of Fisheries and Game
~~73 Tremont Street, Boston 02108~~
100 Cambridge Street, Boston, Massachusetts 02202

April 15, 1968

Mr. Joseph Pastic
1 Westgate A-6
Cambridge, Mass. 02139

Dear Mr. Pastic:

I apologize for my tardiness in sending you the data requested for the Charles River. I do hope it will be a worthwhile contribution to your study.

On the enclosed data sheet I have estimated existing usage by category and by segment and also projected usage with passage of time and with anticipated improvement in quality of water and hence, the environment.

That there is considerable interest in the Charles is evidenced by a meeting this month of various state and federal agencies, hosted by the U.S. Army Corps of Engineers. It seems inevitable to me that tremendous strides will be taken over the next decade to improve this great natural resource. I think only the limits of our imaginations and our economic problems will hinder the potential preservation, enhancement and development of this river and its contiguous flood plains.

There is some basis for determining recreational values that many agencies are now using. This is a publication, "Evaluation Standards for Primary Outdoor Recreation" by the Ad Hoc Water Resource Council, 1964. I am listing dollar values we are using based on this publication. You may assign greater values if you are convinced they are warranted and we would not disagree since we consider these values quoted to be conservative.

fishing - trout	$3.00 per angler trip
fishing - other	1.50 per angler trip
hunting	4.50 per hunter trip
trapping	6.00 per trapping day
bird-nature study	1.50 per day trip

We have in preparation, a study done by a graduate student at University of Massachusetts entitled "Hunter-Fisherman Expenditure Study for 1966" which affixes a dollar figure of $83 million per year spent by Massachusetts sportsmen in pursuit of their sport. It is broken down into numerous categories and may be of interest to you. If you would like me to mail you one when available (about 1 month) I shall be pleased to do so.

Let me know if we can add anything additional to your study.

Yours sincerely,

Paul S. Mugford
State Ornithologist

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Estimated Fish and Wildlife Recreation on Charles River

	Est. Annual Angler Trips	Est. Annual Hunter Trips	Est. Annual Trapping days	Est. Annual Bird & Nature Study Trips	Est. Annaul Harvest Fish, Fur and Game
Segment I (1968)	Trout 1,000 Other 2,000	Waterfowl 1,200 Misc. game 500 mammals Pheasant 10,000	100	3,500	fish 3,500 lbs. fur 1,000 pelts game birds 1,000 game mammals 1,000
Segment II (1968)	Trout 500 Other 500	Waterfowl 50 Misc.game 50	50	1,000	fish 600 lbs. fur 250 pelts game birds 20 game mammals 50
Segment III (1968)	Trout none Other 100	none	none	100	fish 50 lbs.

Potential fish and wildlife benefits to be expected with no change in existing water quality

Year - 1980 = Add 10% overall - Segments I, II, III

Year - 2000 = (Add 100% Trout fishing - Segments I, II
(Add 80% other fishing - Segments I, II, III
(Add 10% hunting - Segment I only
(Add 10% trapping - Segments I, II

Potential fish and wildlife benefits to be expected with upgrading of water quality to no less than classification C (as defined by Mass. Div. Water Pollution Control)

Year 1980 - Add 100% overall

Year 2000 - (Add 200 % Trout fishing-Segments I, II, Other fishing-Segments I,II,III
(Add 50% Trapping - Segments I,II
(Add 50% Hunting - Segments I,II
(Add 50% Bird & Nature Study - Segments I,II

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