# Swedish Environmental Quality Criteria: The Challenge of Classifying Surface Waters

Licentiate Thesis

by

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## *Abstract*


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Sweden has recently presented a new system of Environmental Quality Criteria (EQC) that are expected to support a flexible, goal-oriented approach to environmental management. The EQC of surface water may serve as the basis for implementing the European Union's Water Framework Directive (WFD) in Sweden. Useful as EQC can be for establishing management priorities and monitoring changes over time, though, there is a long-standing concern that the simplifications inherent in assessment systems such as EQC compromise their value. One manifestation of this concern was the two decades of active debate before the official adoption by the Swedish Environmental Protection Agency in 1990. Understanding the concerns which led to this delay may provide useful insights into the challenges of implementing EQC and even the WFD. The aim of this thesis is to improve the understanding of EQC and their implementation by examining the EQC from both scientific and management perspectives. This is done by first presenting a case study of how the new surface water EQC are applied in river basin, and then through a historical study of the decades leading up to the official adoption of the first surface water EQC. The historical study found that it was not so much a definitive resolution of any scientific problems, but rather developments in management strategies, together with a change in the nature of the environmental problems facing Sweden, that were of most importance for EQC finally being not only sanctioned, but touted in 1999 as a key feature of future environmental management in Sweden. The river basin case study found that EQC could make a valuable contribution to environmental assessment, particularly by bringing a broader spectrum of managers, stakeholders and politicians into contact with environmental data and a coherent overview of the situation in a region. The value of that contribution, however, is contingent upon an expert review of the results that identifies potential problems in the specific EQC application where greater expertise is required for a satisfactory assessment.



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## *Sammanfattning*

Lindberg, J., 2001. Swedish Environmental Quality Criteria: The Challenge of Classifying Surface Waters. Licentiatavhandling, Uppsala.
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Nyligen presenterade Naturvårdsverket (NV) ett nytt verktyg för bedömning av miljö-kvalitet som skall användas i miljömålsarbetet, bedömningsgrunder (BG) för sjöar och vattendrag. BG kommer även att användas i implementeringen av EU's vattendirektiv i Sverige. Trots att BG är mycket användbart för prioritering i miljöarbetet och att det ger en möjlighet att se gradvisa förändringar i miljön, finns det motstånd till de förenklingar som är inbyggda i ett bedömningssystem som BG. Under två årtionden diskuterades grundtankarna kring BG. Det var först 1990 som NV publicerade de första officiella BG för sjöar och vattendrag.
I denna licentiatavhandling analyseras BG både ur ett vetenskapligt och ur ett förvaltningsperspektiv. Det ökar förhoppningsvis förståelsen för BG. Avhandlingen består av två artiklar. Den ena beskriver tillämpningen av BG för sjöar och vattendrag i ett avrinningsområde och den andra är en historisk studie av de två årtionden innan BG blev officiellt accepterade. Granskningen av händelseförloppet ger möjligheten att dra lärdom av tidigare utdragna debatter inför den förestående implementeringen av BG. Den historiska studien visar dessutom att det inte var de förbättrade vetenskapliga kunskaperna, som bidragit till att BG accepterats. Snarare var det utvecklingen inom vattenförvaltningen och en samtida miljöförbättring. Studien av tillämpningen av BG i ett avrinningsområde visar, att BG kan vara ett värdefullt tillskott för bedömning av miljökvalitet. Miljöövervakningsdata blir tillgängliga för beslutsfattare, intressenter från industrin och allmänheten, som därmed kan de få en bättre överblick av miljöproblemen i en specifik region. Det är dock viktigt att rimligheten i resultaten av regionala bedömningar granskas av expertis.

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I Bishop K., J. Lindberg, L. Lindeström (2001).
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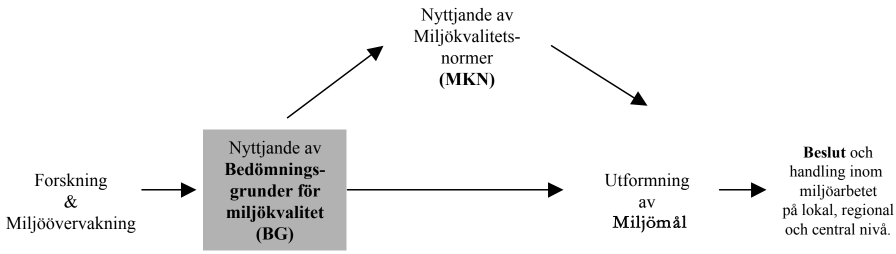
II Lindberg J., K. Bishop, H. Söderberg (2001).
Environmental Quality Criteria for Surface Waters in Sweden: Why it Took Two Decades to Accept a Good Idea.

## *Inledning*

Bedömningsgrunder för miljökvalitet (BG) är ett verktyg som möjliggör tolkning och utvärdering av miljödata (NV 1999:a).

BG är bedömningsmallar för ett urval biologiska, kemiska och fysikaliska parametrar. Syftet med BG är att underlätta för bl. a. länsstyrelser och kommuner att göra riktiga bedömningar av tillståndet i miljön. Utifrån insamlade data erhålls ett bättre underlag för beslut i miljövårdsarbetet generellt och i målstyrningsarbetet i synnerhet. Regeringen lade fram propositionen "Svenska miljömål" 1998, vilken innehåller 15 nationella miljömål, som skall styra miljöarbetet på regional och lokal nivå (Miljödepartementet 1998:b). Kommuner och länsstyrelser skall utifrån dessa nationella mål sätta egna, lokalt anpassade miljömål. BG är tänkt att ha en nyckelroll i detta arbete, eftersom BG visar om det sker en gradvis förbättring av miljön i regionen. BG var efterfrågat och hade stora förväntningar på sig, när de publicerades 1999. Figur 1 visar en schematisk bild av den svenska modellen för miljömålsarbete.




Figur 1. Schematisk bild av hur BG kommer att användas i miljömålsarbetet. BG kan visa gradvisa förbättringar av miljön i en region och användas i arbetet med utformning av lokalt anpassade miljömål och miljökvalitetsnormer, fritt efter G. A. Persson (SNV 1991).

I föreliggande licentiatavhandling beaktas svårigheter och möjligheter med BG i två artiklar. I den första artikeln beskrivs hur BG tillämpas praktiskt i Dalälvens avrinningsområde (Lindeström 1999), där fyra parametrar för sjöar och vattendrag analyseras. I artikeln identifieras vetenskapliga utmaningar som kvarstår inför BG's implementering i svensk miljövård (Bishop m.fl. 2001). Den andra artikeln är en historisk analys av BG. Händelseförloppet mellan 1969 (SNV 1969), när den första versionen BG skrevs, till 1999, när den senaste versionen publicerades granskas (NV1999:a).

Med denna bakgrund ökar möjligheten att dra lärdom av tidigare utdragna debatter inför den förestående implementeringen av BG. Debatterna har delvis kretsat kring de många vetenskapliga kompromisser, som gjorts för att nå den enkelhet som ett verktyg som BG kräver.

Det finns även alternativa miljövårdsstrategier, som konkurrerat ut BG under en längre tid, bl.a. strategin att använda bästa möjliga teknik (BMT) ur miljövårdshänseende (Lundgren 1989:a).

## Syfte

Syftet med denna licentiatavhandling är att öka förståelsen för BG. BG analyseras ur tre synvinklar: 1) Den vetenskapliga utmaningen; 2) Miljövårdsstrategin; och 3) Den praktiska tillämpningen.

## Metod

I avhandlingen visas hur den senaste versionen av de svenska bedömningsgrunderna för miljökvalitet fungerar i ett praktiskt fall och hur BG utvecklats och ifrågasatts i ett historiskt perspektiv.

Artikel I är en demonstration av BG där vi påpekar fördelarna och nackdelarna med verktyget. Artikeln är en vetenskaplig analys av Lennart Lindestöms rapport (1999) "Dalälvens vattenvårdsförening (DVVF) samordnad Vattendragskontroll 1998 - Tillämpning av de nya bedömningsgrunderna". DVVF har tillämpat BG på befintlig miljödata från regionen för den årliga utvärderingen av miljötillståndet i Dalälvens avrinningsområde och gjort en praktisk utvärdering av BG. Tidigare år har de använt sig av ett recipientkontroll program utvecklat av Dalarnas länsstyrelse 1989.

Artikel II är baserad på elva intervjuer och litteraturstudier. Jag har genomfört öppna och riktade intervjuer enligt Annika Lantz teorier (Lantz 1993). Intervjuerna ökar förståelsen för informella skeenden inom NV, som påverkat utvecklingen av BG. De ger en möjlighet att koppla ihop olika avgörande beslut. Mot denna bakgrund visar jag hur de olika BG-projekten i NV regi framskridit.
Alla intervjuer har följt samma intervjumall, men ändrats något inför varje intervju p.g.a. att de som blivit intervjuade har arbetat med BG vid olika tidpunkter, samt att de haft olika roller i arbetet. Många av de intervjuade

har varit projektledare i olika BG-projekt mellan 1968-1999, några har även varit involverade i fler än ett projekt. Litteraturen som använts i artikeln är rapporter från NV, propositioner, PM, officiella anteckningar som tagits vid möten samt, de olika BG, officiella och inofficiella, som NV producerat sedan 1969.

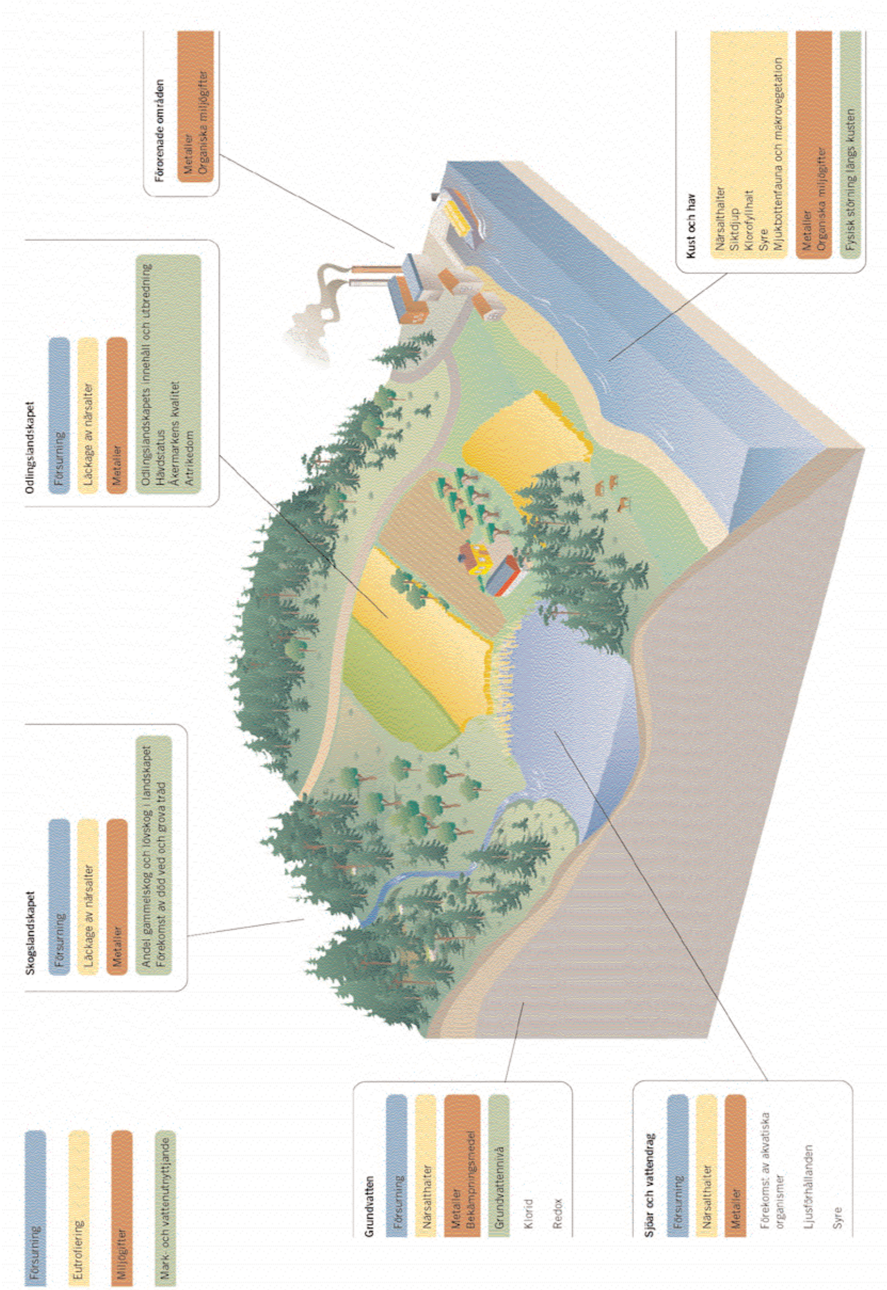
## *Bakgrund*

Sverige har ansetts som ett föregångsland i miljövårdsfrågor under senare delen av 1900-talet (Lundgren 1989). Under 1960-talet fanns det två myndigheter som arbetade med vattenfrågor: Väg- och vattenbyggnadsstyrelsen och Statens vatteninspektion. I den förstnämnda hade vattenkvalitetsfrågorna en mycket låg profil. Den andra var inriktad mot vetenskap och hade sämre tilldelning av resurser. Många av Sveriges vattendrag var under 60-talet blivit kraftigt förorenade och fiskdöd var vanligt. Det var främst två källor till föroreningarna: den undermåliga avloppsreningen och utsläppen från cellulosaindustrin. Miljöfrågan började ses som ett allvarligt problem. Det behövdes en myndighet som tog ansvaret för miljön. Det ledde fram till grundandet av Statens naturvårdsverk (SNV) 1967 (pers. kom. Isgård 1999-09-08).

SNVs uppdrag var att samla information och kunskap om, samt att bevaka, utveckla och ge råd i miljöfrågor. I enskilda ärenden fattades ofta besluten på det regionala och lokala planet. Det nya Naturvårdsverket (NV) medförde att miljöhänsyn blev inbyggt i den svenska förvaltningen (Lundgren 1989). Erik Isgård, konsult på VVB, fick redan 1967 i uppdrag av Åke Liedberg, limnolog på NV, att utforma de första BG för ytvatten.

## *Bedömningsgrunder idag*

Under 1999 kom NV ut med 6 rapporter, som fick samlingsnamnet bedömningsgrunder för miljökvalitet (fig 2). Bakom dessa rapporter ligger 5 års samarbete med expertis från universitet, länsstyrelser, kommuner, vattenvårdsförbund m.m. Tidigare arbetet med BG är en process som har pågått i 30 år och som har varit omfattande och komplext (Artikel II). Idén bakom bedömningsgrunder är att man skall skapa ett verktyg som ger underlag för miljöplanering för landets län och kommuner. Med hjälp av BG kan man tolka miljödata genom att dels bedöma tillståndet i miljön och dels se hur det uppmätta tillståndet avviker från ett "naturligt" värde, d.v.s. beskriva graden av antropogen påverkan på naturen (NV 1999:b).




Figur 2. 1999 gav NV ut en rapportserie, "Bedömningsgrunder för miljökvalitet". Tillsammans täcker rapporterna merparten av Sveriges ekosystem. Sedan 1969 har Sverige haft bedömningsgrunder för vattenkvalitet för sjöar och vattendrag, dock endast inofficiellt fram till 1990, när BG blev först officiellt accepterade av NV.

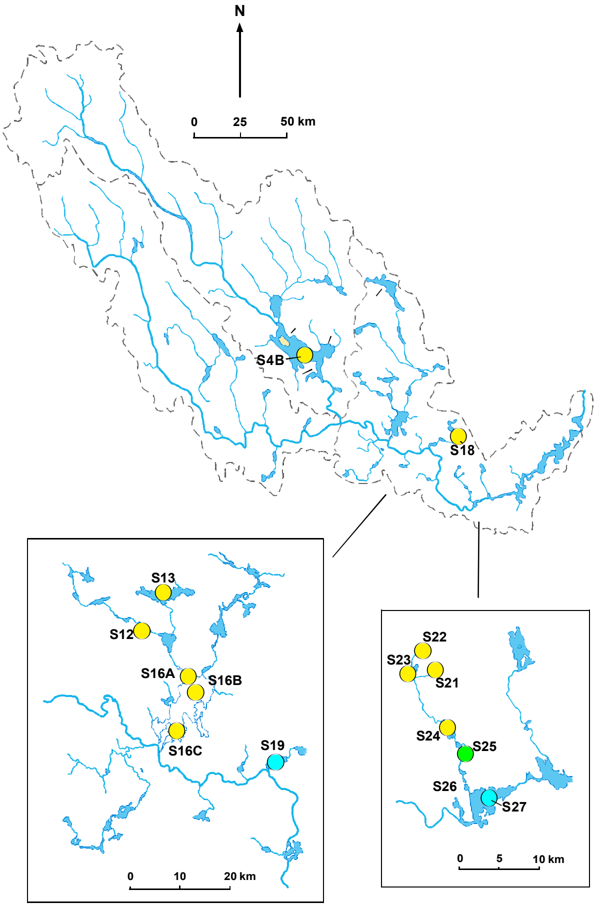
Bedömningsgrunder skall på ett enkelt sätt möjliggöra tolkning och utvärdering av miljödata och samtidigt stå på en stabil vetenskaplig grund (NV 1999:c). I BG klassas analysresultaten av miljödata i fem klasser. Tillstånd bedöms med hänsyn till sitt resursvärde från låga halter till extremt höga halter. Klassgränser for tillståndet är antingen effektrelaterade eller statistiskt fastställda.

Mänsklig påverkan bedöms i intervallet "ingen avvikelse" till "extrem avvikelse" (NV Sjöar och vattendrag/eutrofiering 1999:a) För att bedöma påverkan på miljön använder man sig av ett jämförvärde som skall representera det naturliga tillståndet. Kvoten mellan det bedömda tillståndet och jämförvärdet är den mänskliga påverkan (ekvation 1).

**avvikelse = uppmätt värde / jämförvärde** **Ekvation 1**
(NV 1999:a)

Slutresultatet redovisas på kartor i digital form, där varje provtagningspunkt klassas in i en tillståndsklass, samt en påverkansklass. Varje klass representeras av en färg och det är klassfärgen som markeras på kartan i varje provtagningspunkt.

Många länder har redan utvecklat olika former av bedömningsgrunder. Det svenska systemet är mest likt det norska (Rygg 1993:a). Det som skiljer de svenska bedömningsgrunderna från andra länders, är att det svenska systemet både bedömer tillstånd och mänsklig påverkan.




Figur 3. Ett exempel av en standard presentation av en bedömning med BG. Här bedöms parametern samlat fiskindex avvikelse i sjöar. Bilden är tagen från Dalälvens vattenvårds-förbunds (DVVF) årliga rapport (Lindeström 1999).

## *Artikel I*

### BG applicerat i en region

I denna artikel granskas den praktiska tillämpningen av BG i Dalälvens avrinningsområde och den visar på fördelar och nackdelar med BG. Den vetenskapliga utmaningen åskådliggöras med exempel på praktiska problem där BG används.

Bedömning av miljökvalitet är en viktig del i miljöarbetet. God miljökvalitet definieras av de svenska miljömålen och är olika definierat för grundvatten, sjöar och vattendrag, samt för kust och hav. En gemensam nämnare är att det skall finnas en biologisk mångfald (Miljödepartementet 1998:b). I dagens målstyrda miljöarbete kan man se om man närmar sig eller fjärmar sig det uppsatta målet (pers. kom. Brömssen 1999-11-12). Man har möjlighet att se om miljöåtgärder har verkan eller ej. Man kan också få en överblick som underlättar för prioritering mellan olika mål och miljöproblem. Den stora svårigheten är dock att göra rättvisa bedömningar av tillståndet i miljön, dvs. göra korrekta bedömningar av miljöövervakningsdata. Naturen är påverkad av människan under en lång tid med effekter som framträder på olika tidskalor. Dessutom finns en stor naturlig variation och detta visar sig i miljöövervakningsdata.

Trots att det finns ett behov av verktyg som kan bedöma miljökvalitet, är det många som kritiserar just dessa verktyg. Man anser det omöjligt att standardisera och förenkla bedömningar, eftersom miljön är så komplex (Bishop 1997). Bedömningarna blir inte samtidigt tillförlitliga lokalt och regionalt med samma parameter för klassning av både tillstånd och påverkan.

Nu när EUs ramdirektiv för vatten antagits (Europa kommissionen, 2000). och alla medlemsländer skall utveckla och använda verktyg som bedömer miljökvalitet, är det ännu viktigare att ställa sig de kritiska frågorna: lever dessa bedömningsverktyg upp till förväntningarna? Leder de till en bättre miljökvalitet?

I de svenska BG för sjöar och vattendrag bedöms tillståndet i miljön med hjälp av 39 parametrar för sjöar (26 i vattendrag) och den mänskliga påverkan med 27 parametrar i sjöar (17 i vattendrag). Resultatet av hur fyra av dessa parametrar tillämpats praktiskt i Dalälvens avrinningsområde presenteras. Två av parametrarna behandlar övergödning, den kemiska parametern total fosfor och den biologiska parametern totala volymen av planktiska alger i sjöar. De andra två parametrarna är metaller i vattendrag och fisksamhällenas status i sjöar.

Det första resultatet av pilotstudien var att det var möjligt att använda BG genom att nyttja befintlig miljöövervakningsdata. Detta visar hur ändamålsenligt BG är för svenska miljöförvaltningsresurser.

Bedömningar för total fosfor fungerade väl. Däremot fungerade de biologiska parametrarna mindre väl. Parametern planktiska alger är helt inriktade på att återge sjöarnas näringsförhållanden. I studien visade det sig att de biologiska indikatorerna påverkas av effekter som inte är med i beräkningarna när BG för planktiska alger utformats. Ett exempel på detta är Gruvsjön, en sjö som tar emot gruvavfall. Gruvsjön tar emot mycket näringsämnen och metaller från omgivningen. Eventuell toxisk påverkan av metaller reducerade halten planktiska alger i sjön. Det ledde till en mycket god bedömning av näringstillstånd (dvs. ingen tecken på eutrofiering) och liten mänsklig påverkan när läget är uppenbarligen inte är så. Även bedömningar av fisksamhälle blir anmärkningsvärt "bra" i några av de mest påverkade sjöarna.

I studien upptäcktes också problem med effektbaserade gränsvärden för tillståndsbedömningar för metaller. Dessa gränsvärden skall kunna relateras till biologiska effekter, men kunde ibland inte upptäckas trots att det indikerats av metallparametrarna i BG.

## *Artikel II*

### BG i ett historiskt perspektiv

I Artikel II granskas den svenska miljövårdsstrategin ur ett BG perspektiv med en historisk ansats. Historien bakom de svenska BG åskådliggör den vetenskapliga utmaningen, eftersom många argument mot BG har varit de samma sedan 1969.

Begreppet "bedömningsgrunder" har funnits på NV sedan 1967 (Isgård 1967). Redan i propositionen till miljöskyddslagen från 1969 står det att det skall framställas riktlinjer, i form av bedömningsgrunder, som skall bidra till en bättre miljökvalitet (Justitiedepartementet 1969).

NV var 1967 uppdelat i två avdelningar. Naturresursavdelningen och den tekniska avdelningen. Naturresursavdelningen hade naturvårdslagen som utgångspunkt för sitt arbete. Man arbetade främst med reservatsbildning och skyddsaspekter. Den tekniska avdelningen hade miljöskyddslagen som utgångspunkt för sitt arbete. Denna lag reglerar miljöfarlig verksamhet och bygger mycket på användandet av bästa möjliga teknik. BG hade också sin plats på tekniska avdelningen, men det var framförallt där som BG blev starkt kritiserat (pers. kom. Wiederholm 1999-12-15).

Tongivande personer på den tekniska avdelningen ansåg att den naturvetenskapliga kunskapen var för dålig för att utverka sådana riktlinjer. Om gränsvärden blev för högt satta eller på annat sätt felaktiga så skulle det underlätta för industrin att släppa ut mer miljögifter än vad miljön tålde, vilket skulle skada miljön. Med gränsvärden skulle det vara fritt fram för industrin att förorena upp till detta värde. Ett system med normer skulle därmed inte ha någon praktisk nytta. Den bästa reningen skulle man åstadkomma genom att kräva att industrin alltid använde bästa möjliga reningsteknik (pers. kom. Lindgren 2000-01-18). På NV ansåg dessutom många att det var omöjligt att göra en enhetlig mall för alla vattendrag i Sverige, eftersom varje vattendrag är unikt. Det är i och för sig riktigt enligt Erik Isgård, men det fanns inga alternativ. I en intervju säger han:

*"Man får väl ta detta som ett första steg och sedan får man väl ta fram något nytt när man kan mer"*
(pers. kom. Isgård 1999-09-08).

Förespråkarna för BG hävdade med andra ord att gränsvärden kontinuerligt skulle revideras med nya kunskaper och att man skulle utnyttja de kunskaper man hade.

Ytterligare en anledning till ett ökat behov av BG uppstod i samband med att NV bildades. Då flyttades ansvaret för bedömningar av vattenkvalitet ut på kommuner och länsstyrelser. Tidigare låg det ansvaret hos Statens vatteninspektions (SVI) laboratorier på Drottningholm. Expertkunskaperna för bedömning och analysering av vattenkvalitet som tidigare fanns vid SVI, fanns inte i samma utsträckning på kommuner och länsstyrelser. Behovet av vägledning ökade (pers. kom. Karlgren 2000-01-26).

Frågan om hur BG skall användas i miljöförvaltningsarbetet har funnits med i debatten sedan början av 1970-talet. Verktyget BG har utvecklats i tre steg: normer (1968-1980); övergång (1978-1987) och godkännande (1990- ). I första steget var det tänkt att BG skulle vara rättsligt bindande normer. Huruvida bedömningsgrunder skall vara juridiskt bindande eller ej, har alltid varit föremål för diskussion (Wiederholm 1981). Bl. a. ansåg man sig inte ha tillräcklig kunskap för att sätta rättvisande normer. Här måste man skilja på begreppen normer och bedömningsgrunder. Normer är gränsvärden som inte får överskridas. De ska vara styrande och kopplande till lagstiftning. Idag kan man jämföra dem med de kommande miljökvalitetsnormerna (MKN), som är under utveckling (Gripperth 1999). Bedömningsgrunder däremot är ett stegrande system av gränsvärden, där man använder sig av gränsvärden för att sätta klassgränser. För att komma vidare i arbetet bestämdes det att BG endast skulle vara riktlinjer och ej vara rättsligt bindande. Under en "övergångsperiod" utvecklades och omarbetades de gamla versionerna av BG. 20 år efter den inledande debatten kom de första officiellt accepterade BG, "Allmänna råd för sjöar och vattendrag", och som antogs av NV (SNV 1990).

Att skapa vetenskaplig konsensus i BG var ett av huvudsyftena i den senaste satsningen på BG (1994-1999) och man ansåg det som den svåraste uppgiften. Ulf von Brömssen tar upp detta i en intervju.

*"Begreppet Bedömningsgrunder är ett värdeneutralt klassificeringssystem…Jag tror att den viktigaste orsaken till att det tagit lång tid och krävt stora resurser att utveckla detta koncept har just varit frågan om att på ett vetenskapligt sätt kunna få konsensus kring rätt jämförvärde för användning när man skall beskriva graden av antropogen påverkan."*
(pers. kom. Brömssen 1999-11-12)

Efter många års intensivt arbete har man kommit fram till vad som idag anses som det bästa systemet, baserat på dagens kunskap men med möjlighet till förbättring. Vi kan därför inte säga att den huvudsakliga anledningen till att BG slutligen blivit accepterat har en vetenskaplig förklaring (Artikel II). Det som gör att bedömningsgrunder har en faktisk verkan i miljöpolitiken är att det är granskat och accepterat av centrala myndigheter (pers. kom. Wiederholm 1999-06-07).

Idén om att kunna prioritera miljöarbetet och ha möjlighet att dokumentera förändringar i naturen med BG har alltid funnits vid NV. Tanken var dock lite för visionär då 1960- och 1970-talet präglades av "storstädning" i naturen. "Storstädning" var ett uttryck som myntades av

Valfrid Paulsson, chef på NV 1967-1991, för att beskriva det pågående miljöarbetet. Industrin skulle rena alla utsläpp, men till rimliga kostnader och med bästa möjliga teknik (BAT) (pers. kom. Johansson 1999-10-28). BAT var den mest kostnadseffektiva miljövården vid denna tidpunkt, enligt Paulsson (Lundgren 1989). Prioritering av problemområden i miljöarbetet var onödigt då man koncentrerade sig på punktutsläpp från industrin.

I samband med att Göran A Persson, dåvarande chefen för NV's forskningssekretariat, startade projektet "Normer för vattenkvalitet" 1976, skrev han ett PM, "Riktvärden för vattenkvalité. Bakgrund och arbetsprogram", där han förutspådde att BG behövdes i framtida miljöarbete:

*"Den främsta anledningen till att riktvärden för vattenkvalité inte utarbetats är säkert att man inom Naturvårdsverket inte känt något större behov av sådana värden. Man kan emellertid förutse en ändrad situation i och med att det hittillsvarande s k grovsaneringsskedet håller på att avslutas. Mycket talar för att detta skede måste avlösas av ett prioriterings- och planeringsskede. Det framstår inte längre lika klart som tidigare vilka åtgärder som skall vidtas för att minska utsläppen till vatten. Som underlag för en prioritering av åtgärder och som hjälpmedel i en vattenvårdsplanering skulle ett system av riktvärden för vattenkvalité vara av värde".*
(Wiederholm 1981)

Fyra år senare avbröts projektet då NV inte ville publicera "Normer för vattenkvalitet" (pers. kom. G.A.Persson 2000-01-12).

Motståndet mot BG var främst riktat mot persistenta ämnen som t.ex. tungmetaller. Om det tar lång tid för ett ämne att brytas ner finns möjligheten att det sprids över stora arealer och att de utövar sin verkan under en lång tid. För dessa ämnen borde man ha en säkerhetsgräns som var nära nollutsläpp. (pers. kom. Lindgren 2000-01-28) I sådana situationer behövs BG knappast.

Under 1980-talet kom tiden för prioritering och planering. De stora punktutsläppen var då sanerade och BG behövdes för planering av miljöarbetet. I informationsskriften "Vilken miljökvalitet?" beskriver NV för första gången behovet av BG (SNV 1987). Det målstyrda miljöarbetet som började slå igenom under slutet av 1980-talet, var därför en viktig anledning till att BG accepterades (SNV 1990).

Det har gjorts ändringar i BG sedan 1969 och det har lagts ner mycket arbete på att skapa konsensus i vetenskapssamhället, men det är två andra faktorer som vägt tungt när BG accepterats. Den första är att den gradvisa förbättringen av miljön i Sverige har bidragit till att man måste ha ett verktyg som kan bedöma diffusa utsläpp. Den andra är förändringen från ett centralt, detaljstyrt miljöarbete till ett mer decentraliserat målstyrt miljöarbetet (Artikel II).

## *Slutsatser*

1)Den vetenskapliga utmaningen: Trots decennier av utvecklingsarbete har man inte kommit över problemen med att göra tillförlitliga rutinmässiga bedömningar. Det har snarare visat sig att mer forskning gör det svårare att göra korrekta bedömningar. Detta är dock inte så förvånande eftersom den naturliga variationen i miljön inte är anpassad för generaliseringar.

2)Miljövårdsstrategin: Förändringen från ett centralt detaljstyrt miljöarbete till ett mer decentraliserat målstyrt miljöarbete har skapat ett behov för BG. Det har dessutom förts en diskussion om att expertkunskapen skulle gå förlorad då man använder sig av förenklade bedömningar, vilket dock stämmer dåligt med studien från Dalälven. Tvärtom, genom att först anpassa BG och sen granska med expertkunskaper kan problemområden identifieras för kompletterande studier. Om BG används på detta sätt skulle många av de tidigare farhågorna försvinna. Dessutom blir miljödata tillgängligt för fler aktörer vilket är positivt. BG är trots sina brister användbar som bedömningsverktyg av vår miljö.

3) Den praktiska tillämpningen på Dalälvens avrinningsområde visar att BG är användbart och att utfallet är tillräckligt pålitligt för att kunna användas för vissa parametrar, trots att det fanns klara problem med andra parametrar i specifika situationer. Det är därför mycket viktigt med kontinuerliga uppföljningar av BG och att tillämpningar granskas av experter.

## *Avslutning - om framtiden*

Efter att jag nu beskrivit hur bedömningsgrunder fungerar i praktiken och hur BG sakta tagit form under 30 års tid, följer vidare arbete med granskning av BGs implementering. Jag kommer att arbeta utifrån tre huvudfrågeställningar.

- Hur väl passar BG in i andra miljökvalitetssystem?
- Ger BG tjänstemän på kommuner och länsstyrelser den bild av tillstånd och påverkan av naturen som experterna tänkt sig?
- Kommer BG att förändra miljöpolicy i län och kommuner enligt NVs intentioner?

## Koppling mellan BG, vattendirektivet och miljökvalitetsnormer

EUs ramdirektiv för vatten (Europa kommissionen 2000) kräver att varje enskilt medlemsland har ett bedömningssystem som har vissa likheter med våra svenska BG. Nu när EUs ramdirektiv för vatten antagits pågår arbeten på myndigheter, länsstyrelser och kommuner med att anpassa de svenska BG till detta direktiv.

I Sveriges nya miljöbalk (Miljödepartementet 1998:a), som trädde i kraft 1999, finns det krav på att utveckla miljökvalitetsnormer (MKN). De nya miljökvalitetsnormerna kan eventuellt komma att ersätta delar av BG i framtiden, då dessa införlivas i MNK. Det finns stora skillnader mellan MNK och BG. BG är ett generellt verktyg som används för policyarbete, med möjlighet att tillämpas i olika regioner. MNK är ett bestämt gränsvärde för högsta tillåtna utsläppsnivå, som tillämpas i en specifik sjö eller vattendrag. BG är ej juridiskt bindande, medan MNK är det. MNK påminner mycket om de tidiga BG. - Kommer det att gå att införa normer idag?

## En internationell jämförelse

Vissa EU länder som t.ex. Frankrike, Holland och England använder bedömningsverktyg i sitt miljövårdsarbete (Gustafsson 1989). EUs ramdirektiv för vatten kräver att alla medlemsländer skall ha "bedömningsgrunder för vattenkvalitet" och att de skall vara samordnade. Inget land skall kunna ha lägre krav på vattenkvaliteten och därmed skapa ekonomiska fördelar (Europa kommissionen 2000). För att kunna utvärdera BG på ett effektivt sätt skall vi jämföra de svenska BG med övriga bedömningsverktyg både i Europa och Nordamerika. I USA implementeras just nu del två av "Clean water act" den mer ekologiskt inriktade delen, en form av BG. En jämförande studie mellan USA och Sverige kan ge kunskap åt implementeringen av de svenska BG. Norge kom 1989 ut med "Vannkvalitetskriterier for ferskvann" (Rygg 1993:b). Arbetet pågick samtidigt som NV utvecklade allmänna råd för sjöar och vattendrag. Under arbetet med dessa allmänna råd tittade man mycket på den norska versionen (Rygg 1993:a).

### Bidrar BG till att öka förståelsen för/höja kunskapen om miljökvalitet på länsstyrelser och i kommuner?

BG är utvecklat för att vara ett enkelt och pedagogiskt verktyg. Med hjälp av BG kan tjänstemannen på en länsstyrelse eller kommun göra bedömningar av miljökvalitén i sin region (NV 1999:a). Detta kan leda till att helhetssynen på naturen ökar, och att den naturvetenskapliga kunskapen breddas.

Det kan vara missvisande att återge de naturliga variationerna och den mänskliga påverkan med ett jämförvärde, på det sätt som man gör i BG. Samtidigt försvinner idén med BG som ett lättanvänt och pedagogiskt verktyg, om man ökar antalet jämförvärden och därmed tar bort enkelheten med det jämförvärde som används i BG. Om BG inte är pedagogiskt och användarvänligt kan det lätt leda till att det inte används. Båda aspekterna måste beaktas. Det blir viktigt att se hur väl resultaten faller ut då man använder nuvarande BG, ur en naturvetenskaplig synvinkel. Detta kan förhoppningsvis genomföras genom att låta experterna som tog fram BG granska resultaten.

### Kommer BG att förändra miljöpolicy i Sveriges län och kommuner enligt NVs intentioner?

Vilka konsekvenser får BG, om man tänker på hela kedjan från tjänstemän som arbetar på länsstyrelser och kommuner med att ta prover i sjöar och vattendrag, till resultaten av bedömningarna, kartorna, till de politiska besluten. Politiker har ofta endast lekmannakunskap om naturen, vilket var en viktig aspekt då NV utformade BG. Dagens målstyrda miljövårdsarbete ger möjlighet till deltagande av fler aktörer. Tidigare gav tjänstemän skriftliga rekommendationer som underlag till besluten inom miljövården. Med kartorna, som grundar sig på BG, som beslutsunderlag är det tänkt att politikerna och andra själva kan var mer delaktiga i bedömningar om miljövårdsåtgärder. De miljöpolitiska besluten kan förändras, då politiker och medborgare har tillgång till mer lättförståelig information om miljön. Det ger större insikt i det verkliga läget via miljödata. Detta kan påverka miljöpolicyn i Sveriges län och kommuner och om det blir så är det en utmaning att följa upp. Om miljöpolicyn förändras med hjälp av BG är av betydelse när man ställer frågan, har BG fungerat som det var tänkt?

## *Slutord*

"Vatten är en naturföreteelse men vattenförorening är en kulturföreteelse" så uttryckte sig Johan Asplund 1973 (Lundgren 1986). Jag tror inte att Johan Asplund hade BG i åtanke när han yttrade dessa ord, men de pekar väl på kärnan i BG. Med hjälp av ett verktyg som BG hoppas man att få vattnet att återgå till att vara en naturföreteelse i Sverige. Det är en hög ambition och det återstår mycket att göra. Mycket av arbetet ligger i praktisk implementering hos myndigheter, intressenter från industrin och enskilda medborgare. Den akademiska sektorn kan bidraga genom att kritiskt granska utvecklingen av miljöpolicy och de verktyg som utformar policy - så som BG.

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## *Tack!*

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# Swedish Environmental Quality Criteria and the Challenge of Environmental Assessment: Example from a Major River Basin.

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***Abstract***

Sweden has a new system of Environmental Quality Criteria (EQC) that address the widespread need for assessing the Current Status and degree of Human Influence in the environment. Since EQC is intended for application by many different organizations to provide information that is readily accessible to decision-makers and the public, the system does not require specialist expertise by either those who apply it, or those who use the results. Useful as EQC can be for establishing management priorities and monitoring changes over time, there is a long-standing concern that the simplifications inherent in assessment systems such as EQC compromise their value. This paper examines the performance of four criteria in an application of the Swedish EQC for surface waters to the Dala River Basin. Much of the EQC could be readily applied using existing monitoring data, and some indicators were judged to work well by experts familiar with the Dala River. Other parameters, however, both biological and chemical, performed less satisfactorily. It was concluded that EQC could make a valuable contribution to environmental assessment, particularly by bringing a broader spectrum of managers, stakeholders and politicians into contact with environmental data and a coherent overview of the situation in the river basin. The value of that contribution, however, is contingent upon an expert review of the results that identifies potential problems in the specific EQC application where greater expertise is required for a satisfactory assessment.

## *Introduction*

Assessment is an essential feature of good environmental management that identifies problems, facilitates the establishment of goals, and then follows up on progress towards those goals. However assessing the environment, or more precisely assessing the monitoring data we have about the environment, is fraught with challenges because these data are so complex. This complexity arises in part because human impacts are expressed in many forms over a range of time-scales. Another element of the complexity, though, is the diversity and natural variation of environmental parameters. Finally, the environmental goals of a society are many, and sometimes conflict with one another.

Despite the complexity, effective assessment needs to be applied extensively enough to present a holistic view of the environment. Thus large amounts of disparate types of data need to be collected, processed, assessed and then incorporated into society's decision-making process. Furthermore, this responsibility is often distributed across many local authorities and political institutions where a high level of expertise across the range of relevant environmental issues cannot be expected.

This creates a fundamental dilemma for environmental assessment, in that it should ideally be both intensively detailed and extensively applied by a wide range of non-expert users who will then communicate the results to the public and the political process. Most industrialized societies have grappled with this dilemma and responded with some type of national assessment system, at least with regards to surface water quality. One common feature of many such systems is the standardization and simplification of assessment procedures so that regional and local actors can conduct reliable assessments in a comparable fashion without requiring specialist expertise on the part of those who apply the system or use the results. This is intended to broaden the participation and raise the objective content of environmental management at many levels in society. The recent adoption of the European Water Framework Directive (WFD) has provided an impetus for developing and harmonizing these European assessment procedures with respect to water resources.

While there is a clear interest in developing and using environmental assessment systems, it is also worth asking the critical question - will assessment systems live up to the expectation that they will improve environmental management? It may be tempting to think that the answer is a simple yes. The Swedish experience of environmental assessment, however, suggests otherwise. An assessment system for Swedish surface waters was first proposed in 1969 (Naturvårdsverket, 1969). It took over two decades of active debate and development, though, before the system was officially sanctioned by the Swedish Environmental Protection Agency (SEPA; Naturvårdsverket, 1990). The delay resulted to a large extent from the difficulty of creating an assessment scheme that can be routinely applied in many cases where reliable assessment demands considerable expertise (Lindberg et al., 2001).

A decade after the first EQC for surface waters were adopted, a new set of EQC for surface waters was presented (Naturvårdsverket, 1999a; SEPA, 1999a), together with EQC for five other aspects of the environment (groundwater, coasts and seas, forest soils, agricultural soils, contaminated sites, Naturvårdsverket, 1999b-f; SEPA, 1999b-f). These EQC were the result of four years of consultation between experts and users organized by SEPA. A major change in the new surface water EQC adopted in 1999 was the inclusion of more biological assessment parameters compared to the EQC from 1990. These biological parameters are intended to give a more integrated measure of the Current Status and Human Influence than the chemical parameters. The new biological parameters also bring the Swedish EQC more into line with the WFD that clearly emphasizes biological quality in monitoring and assessment. In Swedish surface waters, the major issues addressed by EQC are eutrophication, acidification and metals.

Many national systems for environmental assessment exist. The system most similar to the Swedish EQC for Lakes and Watercourses is the Norwegian system that also classes surface waters on an integer scale from 1-5 (Rygg, 1993). The hallmark of the Swedish system which sets it apart from other systems is that there are two separate assessments, one of Current Status, and the other of Human Influence. The class boundaries for Current Status criteria are, in so far as possible, chosen to reflect the utility of the natural resource in question. When effect-related class boundaries are not feasible, boundaries are selected to statistically divide the range of contemporary observations. The second assessment, that of

Human Influence, is measured as a ratio between the observed situation and a reference value that is supposed to represent the natural situation (Eq. 1). (The natural situation is not appropriate in cultural environments such as agricultural landscapes where other principles are used (Naturvårdsverket, 1999d). In some cases, it was not deemed feasible to determine a natural reference value, so Human Influence is not assessed in all cases.

$$\textbf{Deviation} = \textbf{Measured Value} / \textbf{Reference Value} \qquad \textbf{(Eq. 1)}$$

A historical analysis (Lindberg et al., 2001) revealed that concerns about both the scientific veracity of EQC, and the practical value of EQC as a management strategy contributed to the 20 year delay in officially adopting EQC. The scientific objections concerned the ability of a simplified system to correctly define the Current Status, but especially the Human Influence on the environment. The administrative concern was that another management strategy, best available technology (BAT) provided a more effective basis for improving the quality of the environment.

Progress in cleaning up major sources of pollution in Sweden led to a situation where earlier, pressing problems were largely resolved and more diffuse sources of pollution remained. The ability of EQC to provide a uniform standard for assessing Current Status and Human Influence throughout the country, and across a range of issues, was a key factor in the eventual adoption of official EQC which facilitate the establishment of priorities for environmental management. Another factor which eased the way for the official approval of EQC was abandonment of the original intention for EQC to be legally binding. In their current form, EQC are intended as guidelines. (It is interesting to note, though, that the WFD will require a legally binding system similar to EQC.)

One of the original concerns about EQC which has persisted is the problem of defining reliable indicators of Current Status and Human Influence. There was an early hope that scientific progress could resolve that issue, but decades of scientific progress have not succeeded in accomplishing that. Therefore the initial Swedish EQC were adopted with a clear statement that further development needed.

| Issue | Parameter | Current Status | | Human Influence | |
|---|---|---|---|---|---|
| | | Lakes | Water-courses | Lakes | Water-courses |
| **Nutrients/ Eutrophication** | | | | | |
| | Total Phosphorus | + | - | + | - |
| | Total Nitrogen | + | - | - | - |
| | N/P quotient | + | - | - | - |
| | Areal N loss | - | + | - | + |
| | Areal P loss | - | + | - | + |
| **Oxygen and oxygen-depleting substances** | | | | | |
| | Oxygen Content | + | + | - | - |
| | Organic matter Total Organic Carbon | + | + | - | - |
| | Organic matter Chemical Oxygen Demand | + | + | - | - |
| **Transparency** | | | | | |
| | Water colour - Platinum (mg) | + | + | - | - |
| | Water color - absorbance 420nm | + | + | - | - |
| | Turbidity - formazine turbidity units | + | + | - | - |
| | Transparency - Secchi Depth | + | - | - | - |
| **Acidity** | | | | | |
| | Alkalinity | + | + | + | + |
| | pH | + | + | - | - |
| **Metals*** | | | | | |
| | Water | + | + | + | + |
| | Sediment | + | - | + | - |
| | Aquatic mosses | - | + | - | + |
| | Concentration in fish (mercury only) | + | - | - | - |
| **Plantonic algae** | | | | | |
| | Total phytoplankton volume | + | - | + | - |
| | Chlorophyll | + | - | - | - |
| | Spring developing diatoms | + | - | + | - |
| | Water-blooming cyanobacteria | + | - | + | - |
| | Potential toxin producing cyanobacteria | + | - | + | - |
| | Biomass Gonyostomum semen | + | - | + | - |
| | Potentially toxic cyanobacteria | + | - | + | - |
| **Aquatic plants** | | | | | |
| | Diversity of submerged and leafy floating species | + | - | + | - |
| **Surface-growing Diatoms** | | | | | |
| | IPS Index | - | + | - | - |
| | IDG Index | - | + | - | - |
| **Bottom fauna** | | | | | |
| | **(watercourses: riffles, lakes: exposed areas of littoral zone)** | | | | |
| | Shannon Diversity Index | + | + | + | + |
| | Danish Fauna Index | + | + | + | + |
| | ASPT Index | + | + | + | + |
| | Acidity Index | + | + | + | + |
| | **(lakes: profundal zone)** | | | | |
| | BQI Index | + | - | + | - |
| | O/C Index | + | - | + | - |

*Arsenic, Cadmium, Cobalt,Chromium, Copper, Mercury, Nickel, Lead, Vanadium, Zinc

Table 1. Parameters judged by the Swedish EQC for Lakes and Watercourses (after SEPA, 1999a). The table continues on the next page.

| Extension of table 1. | | | | | |
|---|---|---|---|---|---|
| **Issue** | **Parameter** | **Current Status** | | **Human Influence** | |
| | | **Lakes** | **Water-courses** | **Lakes** | **Water-courses** |
| **Fish** | | | | | |
| | Number of native Swedish species | + | + | + | + |
| | species diversity of native Swedish species | + | - | + | - |
| | Biomass of native Swedish species | + | + | + | + |
| | number of individual fish native Swedish species) | + | + | + | + |
| | Proportion of carp (cyprinids) | + | - | + | - |
| | Proportion of piscivorous percid species | + | - | + | - |
| | Proportion of salmonids | - | + | - | + |
| | Reproduction of salmonids | - | + | - | + |
| | Acid-sensitive species and life-stages | + | + | + | + |
| | Species tolerant of low oxygenation | + | - | + | - |
| | Biomass proportion of exotic species | + | + | + | + |
| | Combined Index | + | + | + | + |

Extension of table 1. Parameters judged by the Swedish EQC for Lakes and Watercourses (after SEPA, 1999a).

This paper examines the scientific challenges that may await the widespread implementation of EQC in Sweden. The paper does this using the results from a pilot application of the new surface water EQC to a large river basin in central Sweden that was conducted by the watershed association that has been monitoring and reporting on that basin for the last decade. These results are examined with respect to EQC's stated role of supporting flexible, goal-driven environmental management, with a specific focus on the concern about the scientific veracity of EQC in order to ascertain the degree to which that concern was still justified.

In the Swedish EQC for Lakes and Watercourses, 46 criteria are assessed (Table 1), if one treats different metals as one criteria. Current Status is assessed for 39 criteria in lakes, and 26 criteria in watercourses. Human Influence is assessed for 27 criteria in lakes, and 17 criteria in watercourses.

The results for four of these criteria are presented in this paper. Two concern the nutrient Current Status of lakes. One is the chemical parameter, total phosphorus, (TP). The other is the biological indicator, total volume of planktonic algae, which is deemed particularly sensitive to the nutrient status of aquatic ecosystems. The other criteria examined are those for metals in watercourses, and the integrated measure of fish status in lakes.

These criteria were selected to be representative of the success and problems found in the surface water EQC, as well as for illustrating the interrelationships that often exist between different assessment criteria. While this is an evaluation of one national assessment system, it is believed that the problem of simplifying complex environmental data is generic to many other national systems, and will need to be considered in the implementation of Europe's WFD.

## Study Site

The Swedish EQC have been applied to the 29,000 km2 basin of the Dala River which cuts across central Sweden (Fig. 1). The 500 km long river extends from the mountains on Sweden's western border with Norway, though forested inland areas before emptying into the Gulf of Bothnia.

Figure 1 (Fig 3.1, DVVF). The location of the Dala River Basin in Sweden.

Forests cover 75% of the catchment area and almost all of these forests are actively managed for timber and pulp production. Agriculture uses 4% of the river basin. A quarter of a million people live in the basin, with 80% concentrated in the cities and larger towns. The major industries are paper mills, steelworks, and mines. Portions of the river are regulated for power generation. The annual flow at the mouth of the Dala river is 350 m3/s, but this average varies considerably from year to year due to climatic fluctuations.

Most of the basin can be characterized as lightly impacted, but with some areas that have strong, but local, pollution. Together with the varied landscape, climate, and diversity of aquatic systems, this basin is something of a cross-section of Sweden. Thus it is an appropriate basin in which to examine the function of the new EQC.

## Monitoring Data

The environmental monitoring data on which the assessments are based were collected from 34 watercourses, 28 lakes and 4 river mouths using the methodologies specified by the Swedish Handbook for Environmental Monitoring (Naturvårdsverket, 2001). The watercourses are sampled either 6 or 12 times a year, while the lakes are sampled either twice or 12 times a year. Much of this monitoring program has been in place since 1990, making it possible to compute averages over the course of several years where these are stipulated by the EQC. Laboratory analyses were conducted by MeAna Consultants using nationally standardized procedures. The monitoring, and subsequent evaluation of the data were commissioned by The Dala River Water Management Association (DVVF). This is a voluntary organization of members with a responsibility or vested interest in the water resources of the river basin, including industry and representatives for the forestry and agricultural sectors. The DVVF works closely with local government authorities. SEPA has sponsored the application of the new EQC in the 1998 annual report of the DVVF (Lindeström, 1999) under the direction of Lennart Lindeström, ÅF- Environmental Research Group (MFG).

## *Methods*

### Swedish Environmental Quality Criteria - Specific Indicators
### Lake Nutrient Status - Total Phosphorus

Total phosphorus (TP) is one of three chemical measures of lake nutrient status/eutrophication in the surface water EQC (Total nitrogen and N/P ratio being the others). The TP can be assessed either from the seasonal average (May-October) during one year based on monthly samples from the epilimnion, or from the average August values over the course of three years. In this study, the average August value is used. The class boundari-es are related to the established limnological definitions of lake nutrient status oligotrophic (Class 1), mesotrophic (Class 2), eutrophic (Classes 3 + 4), hypertrophic (Class 5).

The reference value for determining Human Influence on TP can be determined in several ways. If studies are available from a period before human influence occurred, or data are available from areas that are not subject to human influence in a region, these data can be used. If such local information is not available (as is usually the case), a generalized "minimum" reference value (TPref mg/L) can be estimated using (Eq. 2) from absorbance at 420 nm in a 5 cm, quartz cuvette (abs f420/5). This is how the reference value was established in the present study.

**TPref mg/L = 5 + 48 * abs f420/5 (Eq. 2)**

| Current Status | | | | Human Influence | | |
|---|---|---|---|---|---|---|
| Class | | Total phosphorus* | Description | Measured/ Reference ** | | Class |
| 1 | Low | < 12.5 | Oligotrophic | < 1.5 | None or insignificant | 1 |
| 2 | Moderately high | 12.5-25 | Mesotrophic | 1.5-2.0 | Significant | 2 |
| 3 | High | 25-50 | Eutrophic | 2.0-3.0 | Large | 3 |
| 4 | Very high | 50-100 | Eutrophic | 3.0–6.0 | Very large | 4 |
| 5 | Extremely high | > 100 | Hypertrophic | > 6 | Extremely large | 5 |

* conc.(µg P/l) May-Oct. **Reference Value from Equation 2

Table 2. Lake Nutrient Assessment (Total Phosphorus Current Status and Human Influence)

### Nutrient Status - Planktonic Algae

Planktonic algae are a fundamental link in the aquatic food web that respond quickly to changes in water quality. The species composition and abundance relations can respond after just a few weeks of a change in chemistry or physical parameters. In the Swedish EQC, several features of planktonic algae related to lake eutrophication are assessed, the total volume of planktonic algae and spring-blooming diatoms. Other measures of planktonic algae assess the risk for toxic blooms. In this study, the total volume of planktonic algae is assessed from the seasonal average between May and October. The class boundaries are keyed to the same classification of nutrient status used for assessing total phosphorus (from Class 1 for oligotrophy, up to Class 5 for hypertrophy.)

When assessing Human Influence, different reference values for natural conditions are set for lowland lakes, forest lakes and mountain lakes. Lowland lakes are assumed to be located on fine grained sediments with over 60% agricultural lands in their catchments. Due to the potential for large swings in the plankton community, especially with moderate to high nutrient availability, the seasonal average from three years is recommended for use in the assessment.

| Current Status | | | | Human Influence | | |
|---|---|---|---|---|---|---|
| Class | | Biomass* | Description | Measured/ Reference ** | | Class |
| 1 | Very small | < 0.5 | Oligotrophic | < 1 | None or insignificant | 1 |
| 2 | Small | 0.5-1.5 | Mesotrophic | 1-2 | Slight | 2 |
| 3 | Moderate | 1.5-2.5 | Eutrophic I | 2-3 | Significant | 3 |
| 4 | Large | 2.5-5 | Eutrophic II | 3-5 | Large | 4 |
| 5 | Very large | > 5 | Hypertrophic | | | 5 |

*(mm3/l) May-Oct. ** Reference Value

Shallow lowland lake: 1 mm3/L
Deep lowland lake, Forest lake and Alpine lake, all 0.5 mm3/L

Table 3. Planktonic Algae Assessment: Current Status and Human Influence

## Metals in Watercourses

The EQC assess the Current Status of a number of different metals in lake water, running waters, sediments and fish. In this study, the concentrations in lake water are reported for seven metals(Cu, Zn, Cd, Pb, Cr, Ni and As), which should be based on three years of data with samples taken at least four times a year. A Current Status of Class 1 implies little risk for the biota. Small risks may exist in Class 2, and in Class 3 some effects can be expected, especially in soft waters with low pH. These effects are disturbances in reproduction or survival of certain species that reduce the number of individuals found. Class 4 and 5 are further elevated risk, with Class 5 associated with effects even after short exposure. Due to the interaction of other water quality aspects (e.g. pH and TOC) with the bioavailability of metals, complementary biological studies are recommended in water with a Current Status of Class 3 or above. Consideration of the deviation from the reference value is also recommmended as it is expected that a higher Current Status class is more likely to be associated with biological effects where the Human Influence is also judged to be high.

The reference values used in the classification of Human Influence are the estimated concentrations in natural, unimpacted water. Locally derived values are recommended, but a generalized set of values are provided. The class boundaries for a particular human influence class (i.e. the ratio between observed and reference values) differ between metals to be more consistent with the boundaries used in the classification of groundwater (Naturvårdsverket, 1999c), coastal water (Naturvårdsverket, 1999b) and contaminated sites (Naturvårdsverket, 1999f).

**Current Status Metal**

| | Class 1<br>Very low | Class 2<br>Low | Class 3<br>Moderately high | Class 4<br>High | Class 5<br>Very high | |
|---|---|---|---|---|---|---|
| Arsenic | < 0.4 | 0.4-5 | 5-15 | 15-75 | > 75 | Concen-tration (µg/l) |
| Cadmium | < 0.01 | 0.01-0.1 | 0.1-0.3 | 0.3-1.5 | > 1.5 | |
| Chromium | < 0.3 | 0.3-5 | 5-15 | 15-75 | > 75 | |
| Copper | < 0.5* | 0.5-3* | 3-9* | 9-45 | > 45 | |
| Nickel | < 0.7 | 0.7-15 | 15-45 | 45-225 | > 225 | |
| Lead | < 0.2 | 0.2-1 | 1-3 | 3-15 | > 15 | |
| Zinc | < 5 | 5-20 | 20-60 | 60-300 | > 300 | |
| Risk of biological effects | None or very little | Little | Primarily in acidic water and in soft water with low concentrations of humus and nutrients | Increased risk | High risk even with brief exposure | |

Table 4. Lakewater Metal Assessment: Current Status. Continues on the next page.

Extention of table 4.

| | Human Influence (measured/reference*) | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| | None or insignificant | Significant | Large | Very large | Extremely large |
| Arsenic | < 1 | 1–2 | 2–5 | 5–9 | > 9 |
| Cadmium | < 1 | 1–8 | 8–15 | 15–30 | > 30 |
| Chromium | < 1 | 1–2 | 2–6 | 6–11 | > 11 |
| Copper | < 1 | 1–2 | 2–4 | 4–7 | > 7 |
| Nickel | < 1 | 1–2 | 2–4 | 4–8 | > 8 |
| Lead | < 1 | 1–8 | 8–15 | 15–30 | > 30 |
| Zinc | < 1 | 1–3 | 3–8 | 8–13 | > 13 |

*Reference Values (ug/L)

| | | | | |
|---|---|---|---|---|
| As (0.2) | Cd (0.003) | Co (0.05) | Cr (0.2) | Cu (1) |
| Ni (0.5) | Pb (0.05) | V (0.1) | Hg (0.001) | |

Table 4 (extention). Lakewater Metal Assessment: Human Influence.

## Fish

As one of the most highly valued, and ecologically complex components of the ecosystem, there are nine different measures of fish conditions that are assessed (Table 1). All of these different measures are weighted together to arrive at a Combined Index of Current Status and Human Influence, which are reported here. This system is based on the North American system for assessing human influence, the Index of Biotic Integrity (Minns et al., 1994). This system should be based on information from regional aquatic systems that are free from human influence, and others where the influence of specific disturbances can be identified. The great extent of human influence, and combinations of influence in Sweden, however, make this impracticable. So in Sweden the system has been based on “typical values” from national fish databases. Class 1 to 5 for Current Status are used on the 95th, 75th, 25th and 5th percentiles for these databases, with approximately half of all existing data falling in Class 3. The classes are ordered so that Class 1 lakes are the richest and the most diverse in Sweden. The most impoverished lakes have Class 5, and Class 3 is the average for Sweden today.

The reference value for assessing Human Influence has also been established statistically. In this case, half of the lakes are assumed to be in Class 1, 25% in Class 2, 15% in Class 3, 5 % in Class 4 and 5% in Class 5.

It is claimed that this adaptation of the classification system to Swedish conditions succeeds in distinguishing the degrees of Human Influence that are seen today (Naturvårdsverket, 2000a-d). Nonetheless, local knowledge is deemed essential in making these assessments, since natural variation can give rise to incorrect interpretation. Data on high elevation (>500 m a.s.l.) and lowland lakes are also limited, which requires particular caution in those areas.

## *Results*

### Nutrient Status in Lakes - Total Phosphorus

The Current Status for TP in most of the lakes (27 of 34) was either Class 1 or 2 (very low to low ), but seven lakes with higher nutrient levels were present, including one which was off the classification scale (Table 5, Figure 2). The generalized reference value for assessing Human Influence (Eq. 2) is expected to result in an overestimate Human Influence. In 6 lakes, the classification for divergence from the reference value gave a Human Influence was higher than that for Current Status (and in one case the Human Influence class was lower). The classification based on TP was deemed to be reasonable, and was suggested for use in future assessments of the Dala River Basin (Lindeström, 1999).

| Name | Nr. | Current Status Class | | | Human Influence | |
|---|---|---|---|---|---|---|
| | | Total Phosphorus | Planktonic Biomass | | Total Phosphorus | Planktonic Biomass |
| Venjansjön | S1 | 2 | 2 | | 1 | 2 |
| Idresjön | S2 | 1 | 1 | | 1 | 1 |
| Särnasjön | S3 | 1 | 1 | | 1 | |
| Siljan, Solviken | S4a | 1 | | | 1 | |
| Siljan, Storsiljan | S4b | 1 | 1 | | 1 | 1 |
| Siljan, Rättviken | S4c | 1 | | | 1 | |
| Siljan, Österviken | S4d | 1 | | | 1 | |
| Skattungen | S5 | 1 | 1 | | 1 | 1 |
| Orsasjön | S6 | 1 | 1 | | 1 | 1 |
| Amungen, Rättvik | S7 | 1 | 1 | | 1 | 1 |
| Stora Ulvsjön | S8 | 1 | 2 | | 1 | 2 |
| Långsjön, Romme | S9 | 2 | 2 | | 3 | 2 |
| Rällsjön | S10 | 1 | 2 | | 1 | 3 |
| Gopen | S11 | 1 | 2 | | 1 | 3 |
| Grycken, Falun | S12 | 2 | 2 | | 2 | 4 |
| Rogsjön | S13 | 1 | 2 | | 1 | 2 |
| Svärdsjön | S14 | 2 | 2 | | 2 | 2 |
| Vikasjön | S15 | 3 | 2 | | 4 | 5 |
| Runn NV | S16a | 2 | | | 2 | |
| Runn C | S16b | 1 | 2 | | 1 | 5 |
| Runn S | S16c | 1 | | | 1 | |
| Ljustern | S17 | 1 | 2 | | 1 | 3 |
| Grycken, Hedemora | S18 | 1 | 2 | | 1 | 2 |
| Amungen, Hedemora | S19 | 3 | 3 | | 5 | 5 |
| Brunnsjön | S20 | * | 5 | | * | 5 |
| Rafshytte-dammsjön | S21 | 1 | 2 | | 1 | 3 |
| Finnhytte-dammsjön | S22 | 1 | 1 | | 1 | 1 |
| Gruvsjön | S23 | 3 | 1 | | 4 | 1 |
| Åsgarn | S24 | 3 | 3 | | 4 | 5 |
| Forssjön | S25 | 4 | 5 | | 4 | 5 |
| Bollsjön | S26 | 3 | 3 | | 4 | 4 |
| Bäsingen | S27 | 2 | 2 | | 2 | 3 |
| Rossen | S28 | 1 | 2 | | 1 | 2 |

*Value too high for classification

Table 5 The nutrient Current Status and Human Influence in the monitored lakes of the Dala River Basin based on 1) the mean August TP level in the epilimnion between 1990 and 1997 in lakes, and 2) total biomass of planktonic algae between 1990 and 1997.

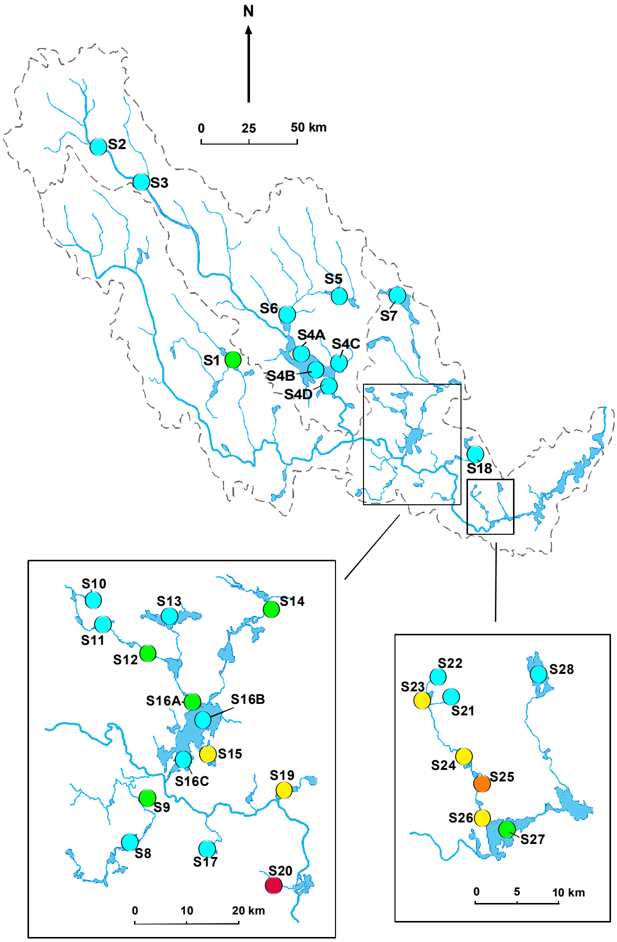


Figure 2 (From Fig. 6.1 in DVVF Report) Current Status with respect to nutrients as assessed from Total P levels in lakes.

## Nutrient Status - Planktonic Algae

The Current Status for the mass of planktonic algae was very small to small (Class 1 or 2) in most of the lakes in this study, which indicates oligotrophic to mesotrophic conditions. Only five lakes had moderately high biomass (Class 3), and two had very high biomass (Class 4).

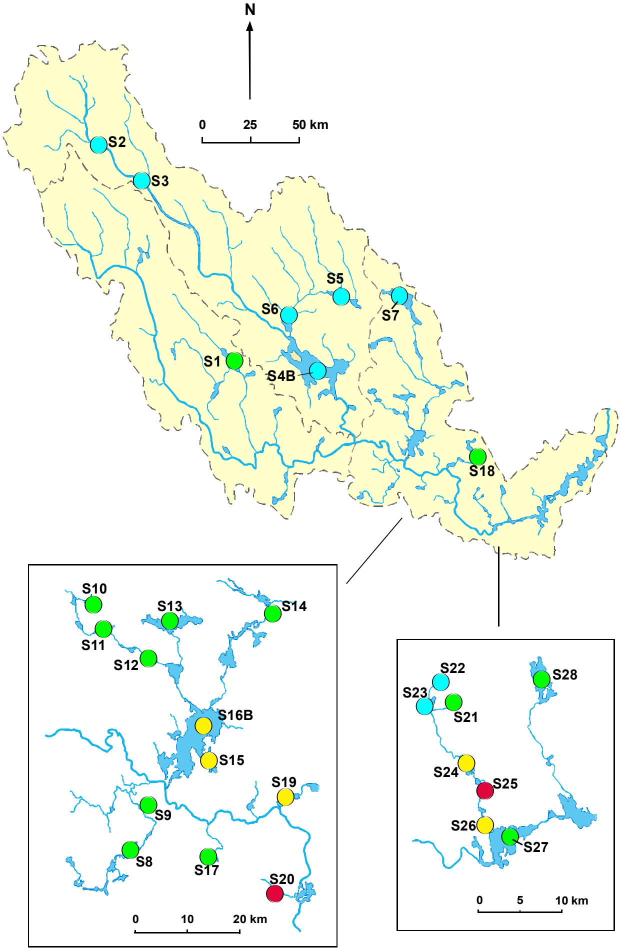


Figure 3 (From Fig. 6.8 in DVVF Report) Current Status with respect to planktonic biomass, which is interpreted primarily as an indicator of nutrient status.

The reference values for determination of Human Influence were made using the generalized values for each of the four lake types in Table 2. It was difficult to classify a number of the lakes though, since the criteria are not unique, as for example the case of "lowland lakes". In the Dala River basin, lowland lakes often had very little agricultural area when an agricultural area over 60% is specified as a feature of lowland lakes (EQC, Table 2). This ambiguity introduced some uncertainty into the assessment of Human Influence. Regardless of the reference values used for borderline lakes though, there was a greater degree of Human Influence in more lakes than Total P had indicated.

The classification of planktonic algae is designed as an indication of nutrient status. This classification, however, can be confounded by the toxic effect of metals as exemplified by Gruvsjön (S23). This lake is downstream from a major mining area, and has some of the highest metal concentrations as well as relatively high nutrient concentrations. According to the TP criteria for nutrient Current Status, Gruvsjön has a very high degree of nutrients (Current Status Class 3) and human induced eutrophication (Human Influence Class 4). According to the planktonic biomass criteria, however, Gruvsjön has the best class with regards to Current Status and Human Influence (Class 1 in both cases).

Thus the toxic effects of metals resulted in a very favorable classification of the lake by this biological indicator, even though biological indicators are often claimed to be a better integrated measure of environmental conditions. A measure of the diversity of the planktonic algae community might have been a better integrated measure of Current Status and Human Influence than total biomass of planktonic algae, while the chemical measures are better suited for assessing nutrient status. Human Influence assessment is also hindered when using the generalized reference values by the lack of clear guidelines for calculating those values.

### Metals in Watercourses

In most of the watercourses of the Dala basin, metal concentrations have a Current Status of very low to low (Class 1 or 2). Several major inputs of metals, however, can be seen downstream from mines ( Sites 26, 34 and 34a). The high class values in such sites are expected to be related to clear effects on the biota.

Since the Current Status class boundaries for metals have been set to reflect effects, relatively high levels of metals deemed less toxic can be found in a low Current Status class. For instance zinc has a Class 1 value that is relatively high relative to background levels now seen in the Dala region, whereas cadmium has a Class 1 boundary that is crossed by more of the waters in background areas. This differentiation in the Class 1 - Class 2 Current Status boundary value effects the degree of enrichment in a metal from a low Current Status (risk) class to a high Current Status (risk) class. In the case of zinc, there is a 12 fold factor between Class 1 and 4, whereas for cadmium, a 30 fold increase in concentration is needed to move a stream from Class 1 to Class 4. This could be interpreted as zinc being more toxic, when in fact it was the greater toxicity of cadmium that set a low Class 1 Current Status boundary, and thereby contributed to the greater "enrichment" needed to get a high risk classification. Similar discrepancies between metals are noted for the ratio between observed values and reference values needed to give a certain Human Influence class (Table 4). For instance, zinc requires a divergence ratio of 5, whereas cadmium needs a ratio of 13 to be in a high Human Influence class (Class 4). The reason given for this differentiation is to achieve more consistency with groundwater and coast/marine EQC, but this occurs at a cost to the internal consistency of the metal assessment for surface waters.

Considerable difficulties also exist in determining the background levels of these metals, not least because other aspects of water quality are likely to effect the natural levels. In light of these difficulties, the DVVF evaluation argues for at least internal consistency in the classification of Current Status and Human Influence for metals in surface waters.

It was also deemed wise to follow the EQC recommendations to make complementary biological studies in areas classified as likely to be suffering from biological effects.
Biological studies in some of the lakes classified as subject to serious effects have in fact, failed to reveal significant influences.

| Name | Nr. | Copper | | Zinc | | Cadmium | | Lead | | Chromium | | Nickel | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | CS* | HI* | CS | HI | CS | HI | CS | HI | CS | HI | CS | HI |
| Fulan | 2 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 2 | 1 | 1 | 1 | 1 |
| Yttermalung | 5 | 1 | 1 | 1 | 2 | 1 | 2 | 1 | 2 | 2 | 2 | | |
| Dala Järna | 7 | 1 | 1 | 1 | 1 | 2 | 2 | 1 | 2 | 1 | 2 | 1 | 1 |
| Mockfjärd | 8 | 2 | 1 | 1 | 1 | 1 | 2 | 1 | 2 | 1 | 1 | 1 | 1 |
| Idre | 9 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 2 | | | | |
| Rot | 12 | 1 | 1 | 1 | 1 | 2 | 2 | 1 | 2 | | | | |
| Rotälven | 13 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 2 | | | | |
| Mora | 16 | 2 | 1 | 1 | 1 | 1 | 2 | 1 | 2 | 1 | 1 | 1 | 1 |
| Oreälven | 17 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 2 | | | | |
| Gråda | 18 | 2 | 1 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 1 | 1 | 1 |
| Forshuvud | 19 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 2 | 1 | 1 | 1 | 1 |
| Kvarnsveden | 20 | 2 | 1 | 1 | 1 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 1 |
| Tunaån | 22 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 3 | | | | |
| Torsång | 23 | 2 | 1 | 1 | 2 | 1 | 2 | 2 | 2 | 1 | 1 | | |
| Varpans utlopp | 25 | 3 | 4 | 2 | 3 | 2 | 2 | 2 | 2 | 1 | 1 | | |
| Slussen | 26 | 5 | 5 | 5 | 5 | 5 | 5 | 3 | 5 | 2 | 2 | | |
| Lillälven | 27 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | . | | | |
| Ljusterån | 28 | 2 | 2 | 3 | 4 | 2 | 3 | 2 | 3 | . | | | |
| Långhag | 29 | 2 | 2 | 3 | 3 | 2 | 2 | 2 | 2 | 1 | 2 | | |
| Långshytteån | 30 | 2 | 2 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 5 | 2 | 5 |
| Herrgårdsdammen | 34A | 4 | 4 | 5 | 5 | 4 | 5 | 4 | 3 | | | | |
| Forsån | 34 | 3 | 5 | 4 | 5 | 3 | 5 | 2 | 5 | 2 | 3 | | |
| Näs bruk | 35 | 2 | 2 | 3 | 3 | 2 | 2 | 1 | 2 | 2 | 2 | 1 | 1 |
| Gysinge | 37 | 2 | 2 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 2 |
| Älvkarleby | 38 | 2 | 2 | 3 | 3 | 2 | 2 | 2 | 3 | 1 | 2 | 1 | 2 |

CS* Current Status
HI* Human Influence

Table 6 (From Table 6.10 in the DVVF Report with Avvikelse calculated from Bilaga 13 in the official manner). The metal Current Status and Human Influence in the monitored lakes of the Dala River Basin based on the mean average concentrations between 1990 and 1997.

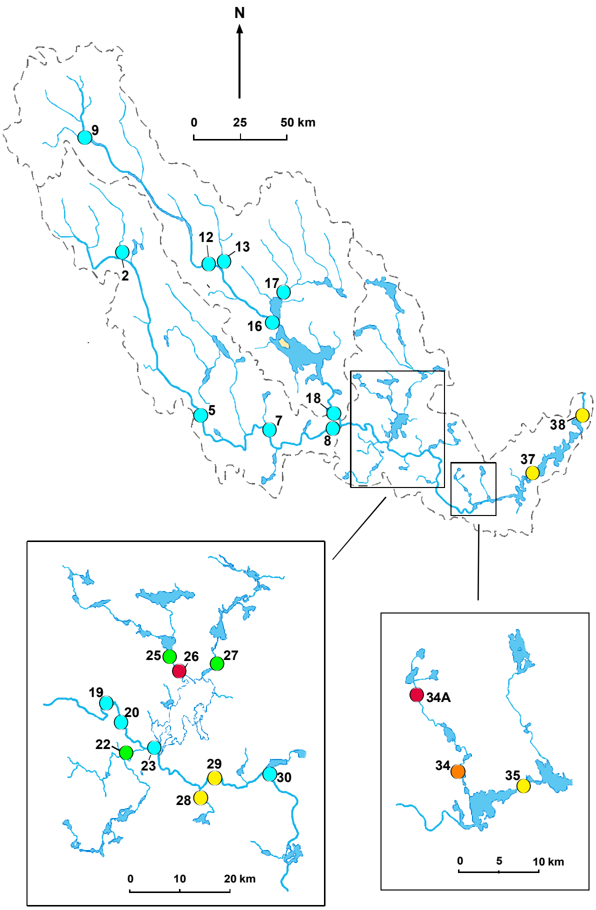


Figure 4 (From Fig. 6.5 in DVVF Report). Current Status with respect to zinc as assessed from mean values between 1990 and 1997.

## Fish in Lakes

Most of the lakes studied had a Current Status of Class 3. Due to the statistical basis used in this classification, this means they were in the median 50% of Swedish lakes. No lake had a higher Current Status class (i.e. poorer with respect to species and number of individuals), whereas several were in the lowest class, with the most rich and diverse composition. The degree of Human Influence was very low to low (Class 1 or 2), with one exception. That exception arose from a large number of young cyprinid (carp family) fish having been caught there.

One might expect that this combined index would give the most reliable indication of Human Influence on a lake. Surprisingly, two sites which were downstream from major pollutant sources (a paper mill and mining - Forssjön, and a steel mill - Amungen) were two of the three sites with the lowest Human Influence (Class 1). Both of these sites also had the best fish Current Status (Class 1). As in the case of planktonic algae, the toxic effects of metals confound the classification system that is designed to measure other threats, such as eutrophication. Other examples were also noted, such as a lake classified as acidified due to a lack of roach (Rutilus rutilus), when most likely there were other causes for the absence of this fish species given the high pH and buffering capacity of the lake.

The official EQC recommend caution in the application of the integrated classification of fish EQC without good local knowledge. The DVVF study suggested that some of the more useful, specific fish assessments, such as biodiversity, and catch per unit effort could be used, but that an integrated measure better suited to the conditions in the region was needed.

| Name | Nr. | Combined Index | |
|---|---|---|---|
| | | Current Status | Human Influence |
| Siljan, Storsiljan | S4b | 3 | 2 |
| Grycken, Falun | S12 | 3 | 1 |
| Rogsjön | S13 | 3 | 1 |
| Runn NV | S16a | 3 | 4 |
| Runn C | S16b | 3 | 2 |
| Runn S | S16c | 3 | 2 |
| Grycken, Hedemora | S18 | 3 | 2 |
| Amungen, Hedemora | S19 | 1 | 2 |
| Rafshytte-dammsjön | S21 | 3 | 1 |
| Finnhytte-dammsjön | S22 | 3 | 1 |
| Gruvsjön | S23 | 3 | 2 |
| Åsgarn | S24 | 2 | 2 |
| Forssjön | S25 | 1 | 1 |
| Bäsingen | S27 | 1 | 1 |

Table 7 (From Table 6.16, (and possible 6.17/18) in the DVVF Report). The Combined Index of fish Current Status and Human Influence in the monitored lakes of the Dala River Basin based on fish sampling during 1996.

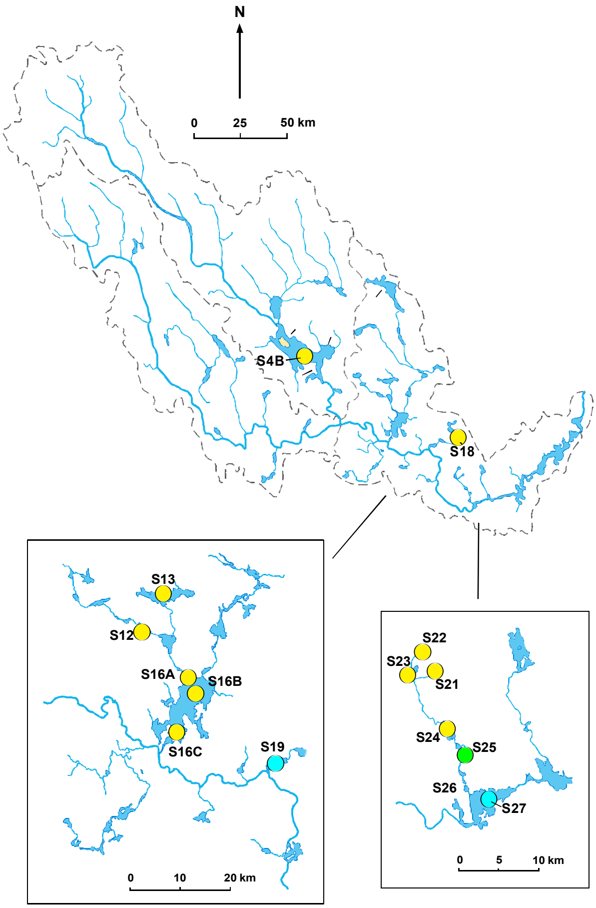


Figure 5 (From Fig. 6.10 in DVVF Report). Current Status with respect to fish as asses sed from mean values of the Combined Index between 1990 and 1997.

## *Discussion*

The first requirement for any assessment system designed for widespread use is that the data specified by the system are available. The Dala River study used routine monitoring data which suggests that the EQC were appropriate to the data available regionally in Sweden. Surveys of local and regional government agencies in 1995 and 2001 also indicated that EQC are widely used (Wiederholm, pers. comm.; Sedin, pers. comm.).

That raises the question that is the central concern of this paper. Do these widely used assessments made with EQC render information that is reliable enough to promote good environmental management. This is one of the central concerns that has followed the Swedish EQC from its conception, namely that the environment does not lend itself to routine, simplified assessments (Lindberg et al., this volume). In recent years, the urgency of this question has been reinforced by controversy about the natural acidity status of surface waters in Northern Sweden. The official reference values classify many waters as acidified, and therefore eligible for remedial liming, whereas a number of scientists have maintained that this reference value is incorrect, and leads to the liming of naturally acid water to unnaturally high pH (Laudon et al., 2001; Bishop et al., in press).
A number of the measures did indeed work satisfactorily in the judgment of the DVVF experts who evaluated the performance of EQC. In the data presented here, TP symbolizes the criteria that functioned well, which included measures of light condition and oxygen availability, among others. But not all of the indicators worked satisfactorily in all situations with respect to Current Status and/or Human Influence.

One of the most difficult aspects of EQC are establishing the natural reference conditions against which Human Influence is judged. Indeed difficulties were noted in determining such reference conditions for several of the criteria reported here, metals and total planktonic algae. Where the official EQC tried to differentiate ecosystem conditions that lead to different reference conditions, difficulties could also arise in defining those different ecosystem types. This was the case for planktonic algae biomass where a large degree of agriculture is assumed in lowland lakes by the official EQC, but this was not found in the lowland lakes of the Dala River Basin.

Problems were also noted in defining the effects-based class boundaries for Current Status. Even though these were supposed to relate to the risk of biological effects, such effects were often not seen where indicated by the metal criteria. There was also a lack of uniformity in how metals were classified. While there were reasons for this (harmonization with metal classification in groundwater and coastal waters), this detracted from the internal consistency for metals classified in surface waters.

Perhaps the most troubling concern though, was the performance of the biological indicators as exemplified by planktonic algae and fish. The integrated nature of these criteria has often led to the claim that they are better indicators of ecosystem Current Status and Human Influence than more traditional chemical indicators. And indeed the new European Framework Directive for Water emphasizes the use of biological indicators as preferable to chemical indicators. The biological indicators in this study, however, proved susceptible to interference from effects not considered in the design of the indicators.

In lakes with high nutrient availability that also received mine drainage, the toxic effects of metals apparently reduced the algal biomass. This resulted in Lake Gruvsjön (literally "Mine Lake") getting the best Current Status for lakes when in fact there were unnaturally high levels of both metals and nutrients in that lake. The integrated fish assessment also failed to indicate some of the most heavily impacted lakes, while citing impacts from acidification where that was clearly not seen in the chemical data (Lindeström, 1999).

Thus decades of development have not overcome the difficulties of making reliable routine assessments. If anything, the accumulated weight of scientific research tends to underline how intractable the problem of simplification/generalization is. This should not be surprising though, as the diversity of nature is not suited to uniform evaluations, even though such evaluations are politically expedient, and often seen as a requirement for effective management (Bishop, 1997).

The difficulties with EQC parameters, however, do not mean that they should be abandoned. The need for EQC, or a similar system is clear. Such assessments bring a large amount of information into the decision-making process that might otherwise not be used. There is also the democratic dimension of introducing more actors to the data and their assessment than can be the case without an assessment system. Furthermore, EQC help in identifying priorities when establishing environmental goals, and offer a means of evaluating progress towards achieving those goals. In that way EQC is a key element of the flexible, goal-driven approach to achieving progress towards a sustainable society which Sweden has adopted as a part of its work with Agenda 21 (Naturvårdsverket, 2000g). The key to the success of EQC is not that the system is perfect, but how the inherent imperfection of the system is accommodated in the decision-making process.

A central concern during years of debate about the risk of EQC over-simplifying nature was that the role of environmental experts, with their uniquely comprehensive insight, would be lost from the decision making process (Lindberg, 2001). That risk is most definitely real, but there is also a possibility that expertise might be used more effectively with EQC. The initial application could be left to non-experts, but those results could then be screened by experts to identify difficult areas requiring further investigation. Indeed the application of EQC to the Dala River Basin is an example of just how expert judgment can differentiate between the reliable and unreliable aspects of the assessment.

If such expert review of the initial EQC assessment is widely used, then the pitfall of EQC misleading the public and politicians with incorrect evaluations could be ameliorated and allow society to benefit from the positive aspects of EQC. The scientific difficulties need to be borne in mind, not used as an excuse to skip the kind of initial overview provided by EQC. Indeed the text of the EQC manuals repeatedly call for expert judgment to be used in the more difficult aspects of assessments. By the same token, though, this study also shows that failure to have expert back-up will mean that serious mistakes can occur. While errors will always occur in evaluations, the official status provided by EQC increases the risk that erroneous assessments, if not detected, will lead to inappropriate policies. This is what some would argue has already happened in the long-running controversy about liming of naturally acid waters that revolves around contested criteria for defining the natural reference conditions for surface water acidity (Bishop et al., in press).

## Conclusion

Swedish EQC are one example of a class of decision-support tools designed to provide an effective means of assessing environmental status. This application to the Dala River shows that EQC can readily be applied, and that the outputs are often reliable enough to classify the severity of a range of potential problems, as well as the degree of Human Influence. EQC also lend themselves to following developments in ecosystem quality over time.

There were, however, clearly problems with specific indicators in certain situations. The study also did not support the contention that biological criteria are generally more reliable than chemical criteria when evaluating specific issues. This study thus highlights the need for expert involvement, especially when using biological indicators. Further refinement of EQC is needed, but such systems will always require a degree of expert interpretation to make them work well.

One potential advantage with EQC as an early step in the assessment process is that non-experts come closer to the actual data, and are given an opportunity to familiarize themselves with major features of the situation in a region. This will also give the non-experts more insight into the issues where expert judgment is required. How EQC will actually be implemented remains to be seen.

If the EQC serve as the starting point of a process that engages more actors at the local level, while still leading on to more detailed investigation by qualified experts where ambiguities exist, then EQC could well be a valuable addition to environmental management in Sweden. Only in so far as EQC are used as a complement to local expertise though, and not a replacement for that expertise, can EQC live up to their potential. The Dala River Basin study, and the subsequent evaluation by the Dala Water Quality Association is a good example of how this could work. If, however, EQC are the endpoint of assessment, then there is a serious risk that incorrect judgments will lead to a situation that is worse than without EQC.

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# Environmental Quality Criteria for Surface Waters in Sweden: Why it Took Two Decades to Accept a Good Idea

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## *Abstract*

Establishing criteria for the assessment of environmental quality has been on the political agenda in Sweden since 1967, when it is referred to in the proposition of the first comprehensive law for environmental protection. It took over two decades, though, before the first set of environmental quality criteria (EQC) was officially sanctioned in 1990 by the Swedish Environmental Protection Agency (SEPA). There are two primary reasons why this took so long. First, there was a scientific concern that the complexity of the environment is not suited to the generalisations entailed by EQC. An assessment system that can be applied and used by non-experts requires generalisations that diminish the degree of scientific detail that can be included in the assessments. This trade-off between detail and simplicity is a fundamental tension within EQC. The second set of reasons for the delay arises from disagreement about the best management strategy for protecting the environment. While one camp within SEPA supported EQC, another camp saw EQC as being a hinder to progress, with a potential for abuse. This group advocated best available technology (BAT) as the most effective way to control pollution.

While groups within SEPA were working to develop EQC more or less continuously since 1967, an important part of the explanation for the eventual acceptance of EQC after decades of resistance were changes in the Swedish environment, as well as related development within SEPA

itself. The initial embrace of BAT was in part due to the polluted state of the surface waters during the 1970s. This meant there was little need to make a selection of surface waters that had to be purified. All that was needed was to get on with applying BAT. In the 1980's the status of the environment had improved to a point where the need was more apparent for a tool like EQC to identify priorities for action, as well as to detect gradual changes in the environment. Thus it was not so much a definitive resolution of any scientific problems, but rather developments in management strategies, together with a change in the nature of the environmental problems faced by Sweden, that were of most importance for EQC finally being not only sanctioned, but touted in 1999 as a key feature of future environmental management in Sweden.

## *Introduction*

In 1999 the Swedish Environmental Protection Agency (SEPA) published a set of decision support tools, Environmental Quality Criteria (EQC). These EQC make two assessments. One is of the current status of the environment with respect to its value as a resource. The second is of human influence, defined as how the observed condition deviates from its 'pristine' state. The goal of EQC is to facilitate the use of environmental monitoring data in decision-making at local, regional and national levels. Thus a central feature of these EQC is that they should be applied by staff without an expert background in the specific field of the assessment. The results are then to be reported to local decision-makers (also non-experts). (SEPA 1999:a)

The initial interest in such a system arose in part from the decentralisation of environmental management that started when SEPA was formed in the late 1960's (pers. com. Isgård 1999-09-08). In recent years, the growing interest in Sweden for flexible, goal-driven environmental management has led to the hope that EQC will support such strategies (Department of environment 1998:a). A system that can be applied by non-experts, however, entails sacrificing a measure of scientific detail (SEPA 1999:b). This trade-off between detail and simplicity is a fundamental tension within EQC. There was also a competition within SEPA between EQC and alternative management strategies (pers. com. Isgård 1999-09-08).

Indeed, despite the great hopes for EQC at their official launch in 1999, it had taken SEPA over 20 years to officially accept EQC after such a system was initially presented for surface waters in 1969. It then took almost another decade after the official adoption of the first surface water EQC in 1990 (EQC90), to produce a complete set of EQC for groundwater, coasts and seas, the forest landscape, the agricultural landscape, contaminated sites, as well as an expanded and revised version for lakes and watercourses (EQC99).

Why has it taken so long to accept these ideas? What factors have caused EQC to gain acceptance now? This article addresses those questions, with a focus on the development of EQC for surface waters, which was the forerunner of the EQC that now exist for a number of different environments in Sweden. It is our hope that an understanding of the enduring resistance to the adoption of EQC for surface waters, from both scientific and management perspectives, can provide insight into the challenges that must now be faced in implementing EQC in Sweden and similar environmental decision-support tools in other countries.

To explore the tensions underlying EQC, this paper investigates the three decade history of EQC in three regards: 1.) Scientific challenges 2.) Environmental management strategies and 3) Changes in the Swedish environment. More generally, though, this paper will be a case study of how complex data about an even more complex environment can find a constructive role in environmental management through EQC.

## A short description of EQC

The Swedish EQC are intended to facilitate routine interpretation and evaluation of environmental data by and for non-experts. The synoptic information provided by such data is of particular importance for identifying priorities for management, as well as detecting gradual, and/or diffuse changes in the environment (SEPA 1999:a).

Two distinct aspects of environmental quality are assessed. One is the current status of the environment as a natural resource. The class boundaries for "current status" should ideally be related to the value of the resource for either human use or maintaining other ecosystem functions. If criteria for such boundaries are not available, the boundaries are set statistically to divide the observed range of values. (SEPA 1999:a)

The second aspect assessed is the degree of human influence. This is measured as a deviation from a reference value, which is intended to represent the natural condition. This deviation is the ratio between the observed value and the reference value (Eq. 1).

**Influence = Contemporary Value/Reference Value** **Eq. 1**

(SEPA 1999:a)

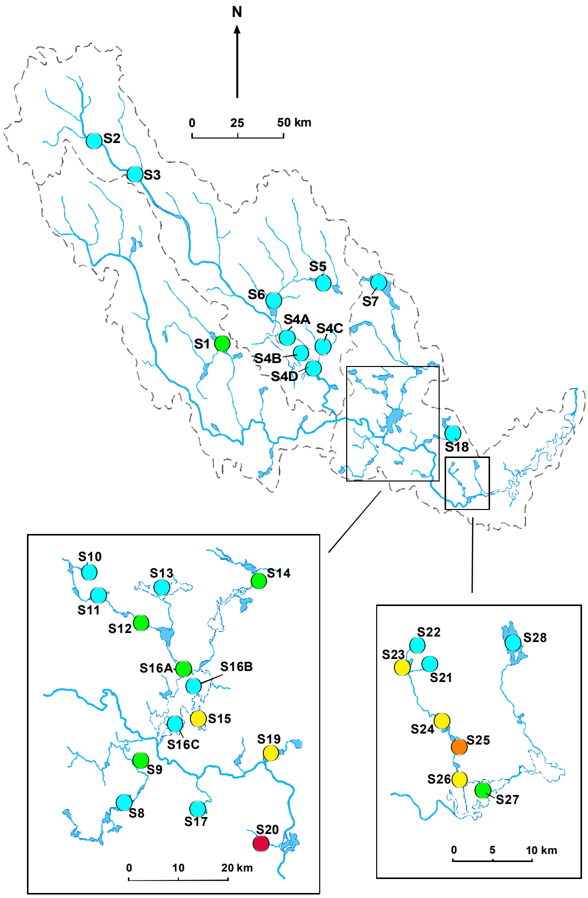


Fig. 1. An example of the EQC classification of current status for lakes with regards to total phosphorus (a measure of nutrient status) in the Dala River Basin (from DVVF 1999). Similar Maps can be created for parameters assessed by EQC with regards to both current status and human influence. (Lindeström 1999)

A key feature of both assessments is adoption of a uniform classification on a scale of 1 to 5. Current status is ranked from high (Class 1) to low (Class 5) resource value. Human influence is also ranked on a five-class scale ranging from little or no human influence (Class 1) to extremely large influence (Class 5). The final result is presented in a standardised manner on maps where each class is represented by a colour (Fig. 1). The uniform classification facilitates comparison of different sites, regions and problems. (SEPA 1999:a)

The EQC have been envisaged as a key link in the Swedish strategy for environmental protection (Fig. 2) and this makes the accessibility to non experts very important. An official set of EQC for surface waters have been in use since 1990 (SEPA 1990). Now EQC are also available for other "media" (e.g. forest soils, seas). It is hoped that EQC will play an important role for environmental management in the future, since the government has decided to pursue a "goal-oriented" approach (as opposed to detailed regulation) for making progress towards a more environmentally sustainable society (Department of Environment 1998).

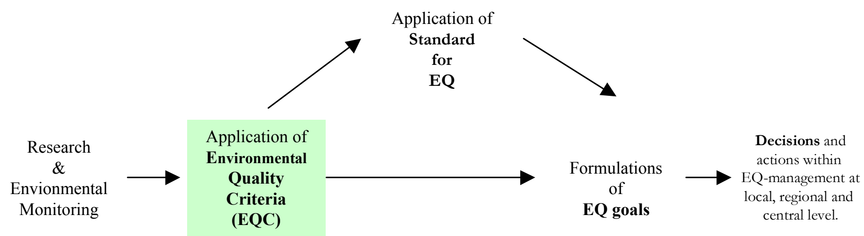


Figure 2. Diagrammatic representation of the role to be played by EQC in environmental management in Sweden. EQC is used in environmental work to see gradual changes of the environment. It is also used to formulate local environmental quality goals and standards for environmental quality.

## *Method*

This article is based on eleven interviews and literature studies. The interviews have been made to understand the informal situation at SEPA at different times. They also link separate events to give a better understanding of the circumstances that can be time dependent. The interview form selected for this purpose is the directed but open interview (Lantz 1993). All the interviews have been conducted in a similar way, but with questions adapted to the time period in question and the role of the interviewee. Most interviewees have been project leaders of SEPA environmental quality criteria projects at some point between 1968 and 1999. Several have been involved in more than one EQC project. The interviews were taped and then transcribed.

This article is also based on documentation that includes SEPA reports, propositions, memos, official notes taken at meetings, as well as publications on EQC that SEPA has produced prior to 2000.

In this paper we start with a presentation of the first EQC and the environmental situation at the time of their inception. A history follows of the debate about EQC as a management strategy. This is divided into three periods. During the first period, EQC were envisioned as legally binding norms. A transition phase followed when the concept of EQC was revised and the ambitions for legally binding status gave way to advisory guidelines. After this came the acceptance phase when EQC for surface waters became official, and EQC for other media were developed (Table 1).

A separate review of scientific developments during the history of EQC is also presented. Scientific progress is a multi-faceted concept that can be judged in many ways. With regards to EQC, that progress is manifested both in changes of class boundaries, and in the degree of acceptance for EQC within the scientific community. In this paper, we document the influence of scientific progress on EQC in the changes of class limits for current status, specifically the boundary between classes 1 and 2. This limit often represents what is thought to be "good" environmental quality (European Commission 2000).

## *The environmental background to the first EQC*

During the decades-long history of EQC, much happened in the Swedish environment and the authority charged with its protection. This background is a valuable starting point for understanding the origin and resolution of the debate about EQC.

By the 1960s, a number of Sweden's watercourses had been badly polluted and death of fish was common. The most important culprit was the paper industry. Almost all watercourses situated near a wood-pulp factory were virtually dead. Sewage discharges had also led to eutrophication of major lakes (pers. com. Isgård 1999-09-08). Sweden entered the 1960's with two separate authorities dealing with water quality: the Swedish Road and Water Building Board (SRWB or Väg- och Vattenbyggnadsstyrelsen in Swedish), and the Swedish Water Inspection (SWI, or Statens vatteninspektion.) In the SRWB, water quality issues had a low profile. The SWI was more focused on water quality and science, but poorly funded (SEPA 1991).

Growing awareness of the need for environmental protection, largely driven by water quality issues, led to demands to create one agency with comprehensive responsibility for the environment. This resulted in the establishment of the Swedish Environmental Protection Agency (SEPA) in 1967. This took over the environmental functions of SRWB and SWI. The new agency was assigned to gather information, monitor the environment, develop policies, and give advice on environmental issues. SEPA helped to integrate environmental considerations in Swedish public administration (Lundgren 1989).

Sweden's first comprehensive environmental protection legislation was introduced in 1969. The environmental protection legislation for water focussed on regulating 'environmentally hazardous activity' in order to deal with the point source pollution that had created so much damage. (Justice Department 1969)

Valfrid Paulsson, the Director-General of SEPA (1967-1992), characterised environmental work during the 1970s as 'a thorough clean up' (Lundgren 1989:b). Industry was to purify all discharge and prevent leakage of environmentally harmful substances from factories. In the view of SEPA, and often the industries/municipalities being regulated, major point-sources of pollution were usually reduced effectively by application of best available technology (BAT) (pers. com. Johansson 1999-09-15). So even though there was an interest in EQC on the part of some at SEPA during the 1970's, it was BAT that was used most during that period (Isgård 1967). The central role for BAT led to a conception of environmental management strategy in that period as very technology-focused (Lundgren 1989).

### *The first EQC*

As a result of the water quality concerns that contributed to the creation of SEPA, some of the new agency's first publications dealt with the issue of assessing water quality (Isgård 1967; SEPA 1969). Another early SEPA publication was guidelines for testing surface waters receiving effluent from pollution sources (SEPA 1968). The impetus for this report was that with the creation of SEPA, the monitoring of water quality previously conducted by the SWI laboratory at Drottningholm was decentralised and transferred to county administrations and municipalities. This created a need for guidance about how to monitor and assess water quality, as the limnological expertise was not always as good out in the local agencies as at SWI and its successor, SEPA (pers. com. Karlgren 2000-01-26). Karlgren's report (SEPA 1968), presented contemporary water quality assessment methods with a strong emphasis on the specifics of sampling, strategies and laboratory methods. Guidance for assessing the results was described in the running text. This report presumes a considerable level of specialised limnological expertise on the part of those conducting the assessment.

This report is not seen as a direct forebear to EQC because it relies on the limnological expertise of the person making assessments. The report is mentioned here to emphasise two different approaches to environmental protection work at SEPA. The alternative to this expert-based approach is that of EQC, which relies on standardised assessment methods that have been simplified to reduce the need for specialist knowledge when evaluating environmental data. Such EQC have been on the political agenda since 1967, when they are referred to in the proposition of Sweden's first comprehensive environmental protection law as a means of providing legally-binding norms for water quality (Grönwall 1998). A simple method for those working on water quality in county administration and municipalities (EQC) was needed to support this legislation.

The assignment to create the first EQC, 'Assessment Criteria for Swedish Surface Water' (1968, Table 1) was given to Åke Liedberg, a limnologist at

SEPA, and Erik Isgård. Erik Isgård was then a consultant engineer at the Hydraulic Engineering Bureau (Vattenbyggnadsbyrån, VBB), with responsibility for water supply and sewerage matters. He asked for a chemist to be taken on board for the project, and Dr Bengt Lundberg, VBB was engaged. Isgård and Lundberg were in charge of assessment criteria for Swedish surface waters. They co-operated with a working team from SEPA, along with experts from universities and other institutes including the Swedish National Board of Fisheries. (pers. com. Isgård 1999-09-08)

The project took its starting-point from international models (pers. com. Isgård 1999-09-08). In 1961 WHO had published "European Standards for Drinking Water" (WHO 1961) and in the USA "Water Quality Criteria" (ATSM 1967) had been issued in 1967. These assessment systems were adapted to Swedish conditions (SEPA 1979). Erik Isgård described this work for the first time in an article in the periodical Vatten, that was entitled "Guidelines for Swedish Watercourses Classification" (Isgård 1967).
Liedberg and Isgård's report (SEPA 1969) presents a classification system for assessing environmental data using numerical ranking and guidelines for mapping the results with uniform colour schemes. Since it is designed to enable non-experts to make assessments in a fashion that could be understood by decision-makers, the report has more in common with the EQC that were finally adopted during the 1990s than Karlgren's guidelines for recipient testing (SEPA 1968).

In fact the 1969 report, Assessment Criteria for Swedish Surface Waters (referred to hereafter as EQC69) had several features that can be seen in the EQC eventually adopted officially in 1990 (SEPA 1990) and 1999 (SEPA 1999:a). To begin with, the presentation method of the contemporary EQC, with maps using a specific colour scheme, was in that first report. More importantly, the first EQC make a distinction between the value of water as a resource, e.g. for bathing, drinking, and fishing on the one hand, and the degree of human influence, termed then as the "status of water from an environmental perspective"

| | Reports | Technical name | Time span | People involved in the different projects |
|---|---|---|---|---|
| Norms – Phase I | **Guidelines for recipient testing** (SEPA 1968) (S:Riktlinjer för recipientundersökningar) | SEPA message V 2 1968 | 1968 | Project leader: Lars Karlgren, director at SEPA limnological survey laboratories at Drottningholm. **1** person involved |
| | **Assessment Criteria for Swedish Surface Water** (SEPA 1969) (S: Bedömningsgrunder för svenska ytvatten) | SNV publication 1969:1 | 1967-1969 | Project leader: Erik Isgård, engineering VBB. Bengt Lundberg, consultant at VBB. Working group at SEPA 5 persons + 7 specialists. A total of **14** persons involved. |
| | **Norms for Water Quality** (SEPA 1977) 4 parts: Eutrophic substances , Organic substances , Metals, Toxic Organic substances. (S: Svenska vattenkvalitetskriterier) | SEPA MEMO 918 | 1976-1980 | Eutrophic substances and Organic substances – Thorsten Ahl, NLU; Metals – Arne Jernelöv, IVL; Toxic Organic substances – Lars Landner, IVL. 3 specialists in each project. Executive group: Göran A Persson (Chairman) + 8 persons A total of **21** persons involved. |
| Transition – Phase II | **Inventory of lakes and watercourses and evaluation of the results** (Lettevall 1982) (S: Inventering av sjöar och vattendrag och utvärdering av resultaten). | SEPA MEMO 1149 | 1978-1982 | Ulf Lettevall, Deputy Director at the Kronoberg county administrative board. **1** person involved. |
| | **Assessment and Guidelines for Phosphorous in lakes and watercourses** (SEPA 1983) (S:Bedömningar och riktvärden för fosfor i sjöar och vattendrag) | SEPA MEMO 1705 | 1983 | Ulf von Brömssen, Torgny Wiederholm, Eugene Welch, Gunnar Persson and Lars Karlgren. A total of **5** persons involved. |
| | **What environmental quality?** (SEPA 1987) (S: Vilken miljökvalitet?) | SEPA informs | 1987 | Göran A Persson (chairman), Ronny Ferm, Rune Frisén, Lars Lindau, Torgny Wiederholm och Björn Wallgren. A total of **5** persons involved. |
| Acceptance – Phase III | **General Guidelines for lakes and watercourses.** (SEPA 1990) (S: Allmänna råd för Sjöar o Vattendrag | General guidelines 90:4 | 1990 | Project leaders: Torgny Wiederholm and Göran Lithner. In the working group: Ulf Lettevall, Per Olsén, Tomas Polfeldt, Kjell Johansson. A total of **6** persons involved (+ a larger reference group). |
| | **Environmental Quality Criteria** (SEPA 1999:c among others) (S: Bedömningsgrunder för miljökvalitet) | SEPA report 4913-18 | 1990-1999 | Lakes and Watercourses (Torgny Wiederholm/Kjell Johansson), Groundwater (Ulf von Brömssen), Coasts and Seas (Sif Johansson), Agricultural Landscapes (Rune Andersson), Forrest Landscapes (Marie Larsson och Thomas Nilsson), Contaminated Sites (Fredrika Norman). Project co-ordinator was Marie Larsson (1995-97) and Thomas Nilsson (1998). There were also reference groups to each project with about 20-25 persons. A total of about **140** persons involved. |

Table 1. SEPA Environmental quality criteria from 1968 to 1999. The reports are divided into three different stages. During the first "Norms" stage, EQC were seen as the basis for legally binding norms as called for by the national environmental protection laws. The second stage was a "transition" when the expectation of legally binding status for EQC was relinquished. Various projects worked to improve the scientific acceptance of the concept of EQC for water quality. These reports form the basis for the work in the third "acceptance" stage when EQC became official. The table also shows how SEPA's investment in developing EQC increases markedly in the third phase, as indicated by the number of people involved in the projects, and the greater amount of time devoted to completion of the reports.

The first three chapters of EQC69 are based on technical reference values adapted to resource values for human use. One example of the central role for human usage is apparent when the group discussed water clarity for bathing beaches,

*"When bathing in an open-air bath the water visibility should be good enough to make it possible to see the bottom before you jump."*
(pers. com. Isgård 1999-09-08)

Human health was also the concern when water supply was discussed. The water should be clean enough that small municipalities could afford to purify it into drinking water. The quality of fishing waters was also related to human health. The fishing water quality should not lead to a levels of substances in the fish that could be hazardous to humans. (pers. com. Isgård 1999-09-08)

In the fourth chapter 'General Environmental Influence', the 'uninfluenced, pristine' aspect of water is considered. To determine how a water body was in its pristine state, natural reference areas were to be located. These references would then serve as the measure of how polluted other watercourses in the area have become. The chapter 'General Environmental Influence' may be seen as a first step towards the assessment of human influence in the current EQC where the status relative to the natural condition is assessed rather than valued as a resource. (SEPA 1969)

Isberg recalls that:

*"Åke Liedberg wasn't interested in the technical aspects [current status of the resource value]. He was more interested in the human influence on the natural condition of the watercourse."*
(pers. com. Isgård 1999-09-08)

In EQC69, the deviation from natural conditions was defined as the ratio between the affected water body and the unaffected water body (Eq. 1). However, no generalised reference values were defined. Instead it was left up to the evaluator to define the reference body of water, presumably located far from cities, industries and agricultural activities. Thus the EQC69 method for assessing human influence was not a standard method, since it still required a high degree of limnological expertise on the part of the user to identify pristine reference conditions. Thus with these first assessment criteria, it was only possible to routinely assess the current status of a water body with respect to its resource value. This is a key difference from EQC90 where there are "default" values for these reference conditions, even though the user is encouraged to find better values than these defaults.

A study done years after the publication of these first EQC (EQC69) found that they were widely used by county administrations, but not by municipalities to any greater degree (Wiederholm 1981). The Swedish Environmental Protection Agency, though, never took a definite position on 'Assessment Criteria for Swedish Surface Waters'. It was issued as a publication in which its authors are stated as being responsible for its content, and was not given official status. The potential that EQC69 would be used as legally binding norms is one reason why those EQC were not officially accepted when they first appeared. It was feared that the legally binding nature of EQC would be too inflexible. Concerns about the scientific reliability of the generalisations and simplifications that went into the standardised classifications also contributed to the initial refusal to officially sanction EQC (pers. com. Isgård 1999-09-08). This is the starting point for the 20 year history of getting EQC officially approved by SEPA.

## *Three phases in the development of Sweden's Environmental Management Strategy and EQC*

### Phase I - Legally Binding Norms

Sweden's comprehensive environmental protection legislation called for an assessment system for water with legally binding norms (Grönwall, 1998). SEPA was to co-ordinate the development of such norms in co-operation with industry trade associations and relevant authorities. The work was to be based on recent scientific findings. The Director of the Agricultural Department thought that Sweden should look internationally in order to find regulatory models with environmental quality norms to work with. He thought that

*"such a system would be valuable in order to give strength and consistency to the application of the generally stated permit rules."*
(Wiederholm 1981)

Torgny Wiederholm, who took part in the development of the norms for eutrophying substances in the 1970's (Table 1, SEPA 1977), says in an interview that there was strong resistance to the idea of such norms from some quarters within SEPA. One argument of the opponents was that setting norms above the natural background values would tie Sweden to a standard of environmental quality that was less then what could be achieved with best available technology (BAT). With EQC-norms it would also be more difficult to increase the level of ambition as technical know-how advanced. This was an especially sensitive issue with regards to non-degradable substances, such as metals and inorganic substances for which the safe level was thought to be zero (pers. com. Lindgren 2000-01-18).

While the opposition to official EQC prevailed during the 1960's and 1970's, there were nonetheless forces within SEPA that wanted to see these EQC made into legally binding norms, which is why this first phase is termed the "Norms Phase" in Table 1. Foremost among those proponents was Göran A. Persson, who joined SEPA in 1967. He became the Director of the Research Department at the Agency in 1974 (pers. com. G.A. Persson 2000-01-12).

Before Persson came to the Research Department he was Director of the Air Pollution Control Bureau within SEPA, and took part in drawing up legally binding norms for air quality.
When Göran A. Persson came to the Research Department in 1974, he initiated work on new assessment criteria, 'Norms for Water Quality' (SEPA 1977). These were planned to consist of two separate documents, one for scientific criteria and another for policy (pers. com. Wiederholm 2000-06-07). Between 1977 and 1980 four criteria documents, the scientific part, were published concerning eutrophying substances, organic substances, metals, and toxic organic substances (Table 1). These criteria documents contain a compilation of pollutants, the effects they have on water quality, and how they affect the use of the water. In order to ensure that the criteria documents were used for management, a policy document was intended to deal with additional factors, such as costs and the future

plans for Swedish water conservation. No policy document was ever written, though. The criteria documents, on the other hand, have been used as textbooks at the university level as well as in the daily work in the Swedish county administrations (pers. com. Wiederholm 2000-12-15; pers. com. G.Persson 2000-03-28).

### Transition - Phase II

During the first phase (1969-1981), the work with EQC was based on the idea of using them as legally binding norms. The scientific and management concerns about the value and accuracy of EQC as norms were an important part of why EQC were not officially adopted during this phase. Towards the end of that period, parallel to the work with the EQC norms documents, another project at SEPA was underway, 'Landscape Analysis for Physical Planning'. This was to provide advice for the inventory and assessment of lakes and watercourses (SEPA 1979). Ulf Lettevall, Deputy Director at the Kronoberg county administrative board, was commissioned to make a limnological investigation for this project. In a letter from Ulf Lettevall dated 19 January 2000 he writes:

*"My point of departure for these thoughts was the Agency's old Assessment Criteria' from 1969. I thought the idea of the Agency's Assessment Criteria was good, but needed to be improved by adopting a more ecological point of view."*
(Lettevall 2000)

In 1982 Lettevall wrote 'A Method for a general description of Water Quality in Lakes and Watercourses' (EQC82, Table 1). In many ways, these are similar to EQC69. For instance, surface waters are assessed both as a resource for human use (Current Status), as well as from the ecological perspective of the degree of Human Influence relative to the natural condition. There are, however, two key features in Letteval's proposal which distinguish it from EQC69, both of which found their way into the first official EQC published eight years later (EQC90; SEPA 1990). One is that human influence was measured relative to a published reference value (rather than an object in nature one had to find). That means less expert knowledge was required to apply EQC82. The second major change is that EQC82 were proposed as guidelines rather than legally binding norms. Shifting from norms to guidelines in the transition phase was a way of circumventing the opposition to norms that would be legally binding under the provisions of the 1969 Environmental Protection Act (Justice Department 1969).

The work in phase II, which included a more detailed consideration of EQC for phosphorus as an indicator of nutrient status (SEPA 1983), helped show that a system of EQC was feasible. This contributed to the acceptance of EQC among the leadership of SEPA. A policy document was written, 'What Environmental Quality?' in 1987, in which SEPA took an official position in favour of EQC - in theory - for the first time. In the preface to this policy document it is stated that:

*"the Director-General has decided that this document [What Environmental Quality?] should, for the time being, serve as guidance for the Agency's future work in these areas."*
(SEPA 1987)

In the quote "these areas" include EQC. This document was not widely spread outside of SEPA, but it marks an agreement within the organisation on where they wanted to go. This also made the work easier for the employees at SEPA, as they now were able to refer to an official policy on EQC, according to Kjell Johansson who has worked at SEPA since 1974, and was involved in many stages of developing EQC for metals (pers. com. Johansson 1999-10-28).

### Acceptance - Phase III

The policy document 'What Environmental Quality?' clarified the internal discussion of how to proceed with the assessment of water quality at SEPA (SEPA 1987). Several years later, in 1990, the report 'General Guidelines for Lakes and Watercourses' (EQC90) was published and given official status. "General Guidelines" is the term given to SEPA publications that provide recommendations for the application of legislation and regulations (SEPA 1999:f). The structure of EQC90 resembles EQC82 in a number of ways, but the scientific content was updated. The new system also had more emphasis on human influence (i.e. the ecological aspect). The parameters addressed in EQC90 were nutrients, oxygen, light, acidity, and metals. All of these were classified on the basis of physical or chemical measurements. (SEPA 1990)

The fact that EQC90 was given the status of general guidelines had been longed-for by Sweden's county administrations and municipalities. Although these general guidelines were not legally binding, they had an official status and this meant an increased administrative clout for those working with these issues. The official status of EQC90 also led to their being used more frequently in the field than their predecessors. (SEPA 1996)

In connection with the publication of 'General Guidelines for Lakes and Watercourses', Rune Andersson of the SEPA Research Department started a discussion with Lars-Erik Liljelund, Director of a unit at the Environmental Monitoring Department, about creating EQC for all aspects of the Swedish environment. Arguments such as the following were made:

- *Sweden's ecosystem consists of more than lakes and watercourses*
- *We are carrying out environmental monitoring in more areas than lakes and watercourses*
- *Since EQC is basically a question of interpretation models for environmental data,*
  *we also need help with data interpretation for other media*

(pers. com. Andersson 2000-02-14)

They discussed the idea of writing assessment criteria for other areas, such as groundwater, forest landscapes, agricultural landscapes, coasts and seas. A project to accomplish this was initiated in 1994. A system for assessing contaminated sites that was already under development was also included. In 1996 a project was also initiated to revise the existing EQC90 for lakes and watercourses. In this new version of EQC90, the leaders of the project, Torgny Wiederholm and Kjell Johansson, agreed that biological parameters should also be included for the first time (pers. com. Johansson 1999-10-28; pers. com. Wiederholm 2000-12-15).

The new EQC for different media got off to a slow start. It took time to formulate the concept, its aims and the planning of the project. Ulf von Brömssen, SEPA's project leader of EQC for groundwater, says in an interview:

*"We have had environmental monitoring in Sweden for a long time. But this monitoring was often a rather passive registration, that is the information hadn't been used. In connection with a discussion in terms of using environmental goals as a management strategy, it became clear that the current status may be classified by means of environmental monitoring. We have environmental goals that we want to see realised in the future, and thus we have a discrepancy between the present situation and the environmental goals. This is where EQC have a place."*
(pers. com. Brömssen 1999-11-12)

The augmented set of official EQC eventually presented by SEPA in 1999 was the result of a five-year-long collaboration between experts from universities, county administrations, municipalities, and water protection organisations.

### Scientific Developments

Creating scientific consensus on the matter of assessment criteria was one of the most important, but also most difficult tasks in creating EQC99. Ulf von Brömssen points out in the interview that it must be clear to everyone that the concept of assessment criteria is not just a matter of setting reference values. Assessment criteria have to objectively describe the current status and human influence. He describes the internal discussions on classifying human influence in the following words:

*"This is really the part that has been most problematic in the development of the assessment criteria concept, since it leads to the question of what 'not anthropogenically influenced' actually means. Should this be a pre-historic state or a pre-industrial state, or should it perhaps be a state which is statistically computed. I think the most important reason why it has taken so long and has demanded such extensive resources has been the very question of getting scientific consensus around the reference value used in describing the degree of human influence."*
(pers. com. Brömssen 1999-11-12)

Ulf von Brömssen mentions human influence as one of the problems with developing EQC99. Eva Öhlund, in the steering committee of EQC99 and Hans Roland Lindgren, who is active on metal questions at SEPA, also point out the difficulty of generalization (pers. com. Ölundh 2000-02-10; pers. com. Lindgren 2000-01-18). EQC has to have a general character but at the same time be able to assess regional and local differences.

This scientific difficulty with EQC was not unique to EQC99, but had been a concern since the inception of EQC. In fact, the scientific concern about the feasibility of EQC was the other major reason, besides considerations about management strategies, for the delay in making an official EQC.

The first EQC proposal in 1969 was met by scepticism on the part of a number of people at SEPA who thought it would be impossible to create a uniform model for all watercourses in Sweden since every body of water was unique. The generalisations required for a simple, uniform classification system would compromise the reliability of the assessment. This was especially true for the assessment of Human Influence. That classification required one, or at most a few regional values of what was natural when it is self-evident that there is a large range of natural values.

Erik Isgård recounts in 1999 that he had initially thought in the late 1960's that this problem could be overcome by advances in science.

*"One will have to see this (EQC69) as a first step, and then, with improved knowledge, some new model will be worked out."*
(pers. com. Isgård 1999-09-08)

There have been three decades for improved knowledge to arrive at a better EQC than that proposed in 1969. And while much scientific progress has been made during that time, it is not at all clear that this has made EQC more feasible or increased confidence in the standardised assessments. This contention is supported by the development of EQC class boundaries, as exemplified here by the Class 1-2 boundary for several parameters, copper, phosphorus and acidity.

It cannot be said that successive versions of EQC have been successively approaching a set of class boundaries that can be expected to stabilise further in future revisions of EQC (Fig. 3).

As mentioned earlier in this article, one scientific concern, closely related to management strategy, were the reference values for metals. A high background value of a non-degradable substance, like a metal, would commit Sweden to an environmental quality that was above a safe level, and what may be technically feasible to achieve. While the scientific content of EQC99 differs considerably from the EQC presented in 1982 and 1999, some of the greatest differences regard classification of metals. The levels in EQC99 considered to be good environmental quality (the Class 1-2 boundary) are sometimes more than an order of magnitude below the EQC82 levels. Between 1982 and 1990 there is a drastic change of the class limits for metals. This shows a trend towards lower tolerance towards metal pollution. This boundary for copper, and many other metals, has increased in EQC99 compared with EQC90. This change for copper is partly because new research shows a higher background value for copper in Lake Mälaren than had earlier been believed (pers. com. Johansson 1999-10-28). For copper, the EQC99 value for the Class 1-2 boundary is forty times lower than that in EQC82. The EQC90 value for copper, however, was sixty times lower than the EQC82 value.

While the boundary changes have often been most dramatic for metals, they have been changing for other parameters as well. The level for good nutrient status has steadily climbed between EQC82, EQC90 and EQC99.

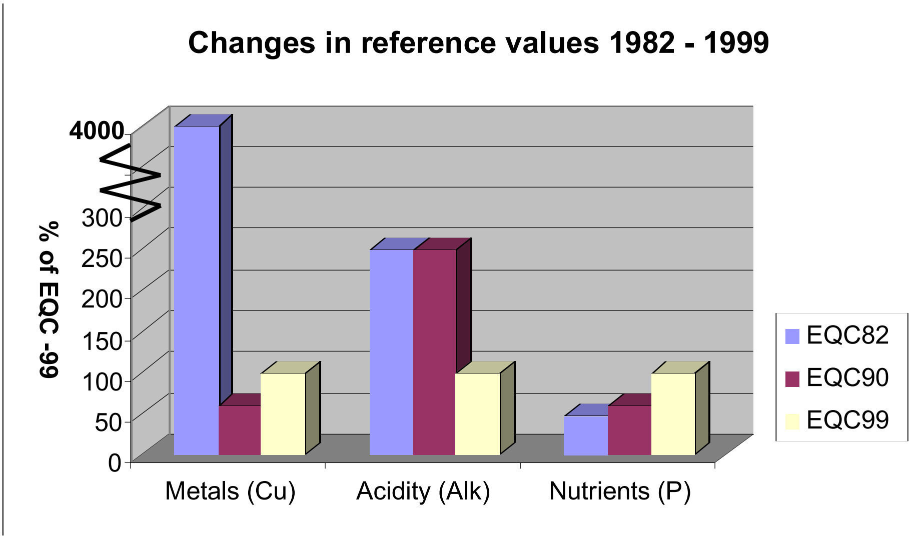


Figure 3. Changes of the value representing the boundary of Classes 1 and 2 between the versions of EQC proposed in 1982, 1990 and 1999. The values are normalised as a percentage of the boundary value between Classes 1 and 2 from EQC -99 for each parameter.

Changes are also noted in the acidity classification. The problem of acidification was only just being recognised in 1967 (Lundgren 1991). In EQC69 acidification was measured in percentage decrease of alkalinity. Up to a 10 % decrease was accepted as a good environmental quality (EQC 1969). The classification of acidification in EQC82 is based on statistical methods with data from regional surveys in Kronoberg County (Lettevall 1984). The delicate question of how contemporary observations are related to pristine conditions was not addressed explicitly.

In SEPA's General Guidelines 88:3 (SEPA 1988) there is a reference value of pH 6 and 0,1 mekv/l for alkalinity. In EQC90 and EQC99, the acidity class boundaries are based on the biological effects of acidification, but the boundary value was reduced in 1999 compared to 1990. Thus even in this area where much research was done in the 1970's and 1980's, it has not been possible to keep a stable set of class boundaries. Not seen in Fig. 2. is the fact that the international reference group working on the acidification classification for EQC99 was so deeply dissatisfied with the way in which natural acidity was dealt with in the human influence classification that they lodged an official letter of protest (Löfgren 1999).

Thus it cannot be said that Isgård's initial hope that more research would solve the scientific problems of achieving reliable EQC has been realised. Instead efforts were made to arrive at the best consensus possible as evidenced from the great amount of time, and broad base of scientific expertise involved in developing EQC99. The possibility of revising values is also an explicit part of EQC99.

## *Discussion*

Two important aspects delayed the initial acceptance of EQC in 1969. One was the scientific concern that EQC69 did not give an adequate representation of the environment. The other was concern from an environmental management perspective that BAT was a more effective alternative to EQC, especially as legally binding EQC-norms could be counterproductive.

The scientific concern arises from the fact that while EQC are supposed to have a solid scientific basis, they make major generalisations that can compromise that scientific basis. Natural variation is particularly difficult to account for in a simple classification scheme. This concern is borne out by the changes of class boundaries with every new version of EQC (Fig. 3).

The eventual acceptance of an official EQC in 1990 cannot be attributed to any definitive resolution of the problem of classifying nature on a scale of 1 to 5. Thus the tension between scientific detail and simplification remains. Three decades of research have often deepened the complexities. But a concerted effort was at least made in EQC99 to gain a broad acceptance of EQC by the Swedish scientific community. It will be interesting to see if the use of EQC will be subjected to scientific criticism, or whether the first generalizations might actually lead to a better awareness among decision-makers of the scientific details which should be further investigated.

The other main reason for not accepting EQC in 1969 had to do with differing views about environmental management strategy. As originally conceived, EQC were to serve as norms. The criticism against norms focused on those areas in which non-degradable substances, such as metals and stable organic substances were involved. The security level of these substances was thought to be zero. Any norm above this level would be a commitment to a level that was not desirable. Once a level was established, it would also be difficult to successively move the level of ambition forward as technical know-how advanced or knowledge of natural levels improved. The concern about the incomplete scientific basis for EQC accentuated the concerns about basing legislation on norms that could be expected to change (pers. com. Lindgren 2000-01-18).

Legally binding norms bring direct pressure for improvements in the environment since polluters are obliged to follow these norms. After the work in the late 1970s with 'Norms for Water Quality', it was decided that the resistance to norms was too strong, so the norm concept was dropp-ped from the EQC. Assessment criteria that are not legally binding could still get influence if they were officially accepted as guidelines by government authorities. This is the flexible approach that now has a central role in Sweden's goal-oriented environmental policies. (pers. com. Brömssen 1999-11-12; pers. com. Wiederholm 2000-12-15)

While the issue of norms could be avoided by treating EQC solely as guidelines without direct legal ramifications, there was a more fundamental management strategy concern about the value of EQC. At the time when Valfrid Paulson's "thorough cleanup" started (about the same time as EQC69 was published without being given official standing), the quality of the aquatic environment in Sweden was poor in many places. (pers. com. Johansson 1999-09-15; pers. com. Isgård 1999-09-08)

At that time, opponents of EQC thought they would not have a practical application. BAT was seen as a more suitable and cost-efficient method for controlling pollution. Indeed, those who advocated BAT regarded EQC as a potential impediment to taking effective action. It was feared that establishing a criteria for what was an acceptable status would create situations where it would not be possible to demand industry to implement pollution-reduction measures if the pollution was below the acceptable quality criteria. (pers. com. Lindgren 2000-01-18)

It is not clear that this fear has any basis in Swedish experience. Isgård points to the Stockholm affair in the mid 1960's as an example that authorities have not been satisfied with anything less than BAT even when quality criteria are not exceeded.

The Stockholm affair in the mid 1960's concerned how much the pollution in Lake Saltsjön should be purified and how low the oxygen level should be. The question was whether BAT should be used to purify as far as possible or rely on a form of EQC to determine the extent of purification needed to reach a level that the environment was able to tolerate. The outcome was that although there was a quality criteria for the oxygen level, one should purify as much as possible with the best available technology, but never less than to the EQC. (pers. com. Isgård 1999-09-08)

Göran A. Persson wrote the following in order to forestall arguments against assessment criteria in a memo in 1976:

*"… it cannot be emphasised enough that a system with environmental criteria for water quality does not mean leaving the field open for polluting up to a certain level. A basic principle in Swedish environmental protection work is that pollution should be limited as far as is technically and economically possible"*

Despite the fact that the fear of EQC being exploited as a license to pollute was not borne out in practice, it was argued by some at SEPA that the best purification would be brought about by demanding industry to always use BAT (pers. com. Lindgren 2000-01-18). BAT was indeed well-suited to the situation during the 1970s, when industry was not as inclined to think in terms of the environment as may be the case more recently.(Wiederholm 1981)

### The Changing Environment and SEPA

By the 1990's, great achievements had been made with respect to reducing eutrophication of inland lakes. An extensive program of liming was in place to counteract the symptoms of acidification, and major treaties had been signed to reduce sulfur emissions in Europe, the principal cause of Swedish acidification. Now that many aspects of SEPA's great clean-up had been carried out, there was a need for a system that could provide a basis for establishing new priorities and goals for further work.

This was a need that Göran A. Persson, one of the early proponents of EQC, had already foreseen in 1976, at a time when BAT was the main-stream management strategy at SEPA:

*"It is, however, possible to anticipate a new situation in connection with the termination of the present, so-called 'cleaning-up stage'. There is much which indicates that this stage will be replaced by a stage of prioritising and planning. It will no longer as clear as it used to be which measures have to be taken in order to reduce water pollution. A system of environmental quality criteria would be valuable as a basis for prioritising measures and in water conservation planning."*
(Wiederholm 1981)

EQC were a better solution than only using BAT once the acute pollution problems had been dealt with. In SEPA's work with action plans during the 1980s (SEPA 1984), and later in the 1990's in the work with environmental quality goals (SEPA 1991:b) (Department of Environment 1998), an instrument like EQC was needed. EQC makes monitoring of the present situation into a means for judging progress towards the environmental goals set by the government.

SEPA has focused on different issues during each of its three decades of existence. While this three decade history of SEPA has never been explicitly analysed, the allocation of funding reveals three, distinct, decade-long foci for SEPA. In the 1970s lakes and watercourses were the centre of attention. The 1980s were the decade of the seas, and the 1990s were the decade of control methodology (SEPA 1991). This clear division of focal points helps explain why it was during the 1970s that SEPA initiated the development of an instrument for environmental quality assessment of lakes and watercourses. This also helps explain why SEPA finally succeeded in presenting its first official assessment criteria for lakes and watercourses in 1990 when regulatory methods were becoming a more central concern.

## *Conclusions*

EQC was launched in 1999 as a major step forward in the efforts to improve the management of the Swedish environment. This hopeful launch of EQC did not call attention to the fact that it had taken SEPA over 20 years to officially sanction a system of EQC. It took a further decade to publish EQC for other aspects of the Swedish environment than surface waters. In this article we have tried to identify the factors which led to resistance to EQC from within SEPA, as well as the factors which eventually led to the official endorsement of EQC.

There were two main reason for the resistance. One was an environmental management concern that EQC were not an effective strategy. In the 1970s BAT was seen as the best solution for the "big clean up" Swedish waters needed. Even the supporters of EQC stressed that the best solution was a mixture of both EQC and BAT. There was also a concern that the difficulty of enforcing legally binding EQC-norms might actually hinder environmental progress.

The other major reason for the initial resistance to EQC was scientific. The simplifications involved in creating a system where non-experts could make standardised assessments would, by necessity, not give the most detailed picture possible of a complex environment. There was early hope that research might improve the veracity, and therefore the acceptability of EQC. If anything, though, three decades of research has confirmed the difficulty of doing justice to the natural diversity of the environment in a

simple assessment system.
Adoption of EQC did not hinge on any definitive resolution of the scientific difficulties associated with EQC. There was, however, considerable investment during the 1990's in achieving scientific consensus that there was no better alternative to the current content of EQC. There is also an explicit promise of opportunity for revision written into EQC99.

The real answer to the scientific qualms, however, will be how well the original concern of oversimplifying nature and a diminished role for experts is addressed in the implementation of EQC. Will the many simplifications lead to many mistakes, or will they pave the way for more detailed assessments where expert assessments are most needed?

There have been some changes within EQC that contributed to their eventual acceptance. Foremost of these was the retreat from legally binding EQC-norms during the 1980's. The most important reason for the official adoption of EQC, however, does not have to do with improvements in the science or structure of EQC. It is rather that the environmental situation, and hence SEPA, requires EQC more now than in 1969. As the environmental status has improved, EQC were needed to help identify new priorities for environmental protection work and follow up progress towards specific goals.

"Assessment Criteria for Swedish Surface Waters" (1969), and its unofficial successors have been used frequently by municipalities and county administrations, although they were only advisory (pers. com. Isgård 1999-09-08; pers. com. Edeman 1999-12-16). Thanks to the refinement of EQC, the efforts to achieve scientific consensus and the changing environmental situation, EQC now have an official place in the Swedish environmental protection work serving as a link between environmental monitoring and environmental goals.

The use made of EQC will depend both on how well EQC fulfils the role for which it was created, but also on whether circumstances still require EQC. In the 1990's EQC fit in well with SEPA's efforts to improve the environment and attain sustainability by means of setting goals (rather than detailed regulation). To some extent, the success or failure of this goal-driven management is entwined with the success or failure of EQC as the means by which progress towards goals is to be judged.

It is clear that the administrative and environmental context within which EQC operates is of great importance for giving that decision support tool relevance. What seems self-evident now, though, was not always so. And it may not be so self-evident in the future. Since the six official volumes of EQC99 were published, the European Union has adopted a Framework Directive for Water. A new, comprehensive environmental law is also being implemented in Sweden. This legally binding legislation will undoubtedly change the administrative setting in which EQC must find its role as it moves off the drawing board into routine use. Even if the need for EQC's advisory guidelines may diminish in the future though, EQC are likely to be the starting point for work with the norms to support the new European and Swedish legislation.

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