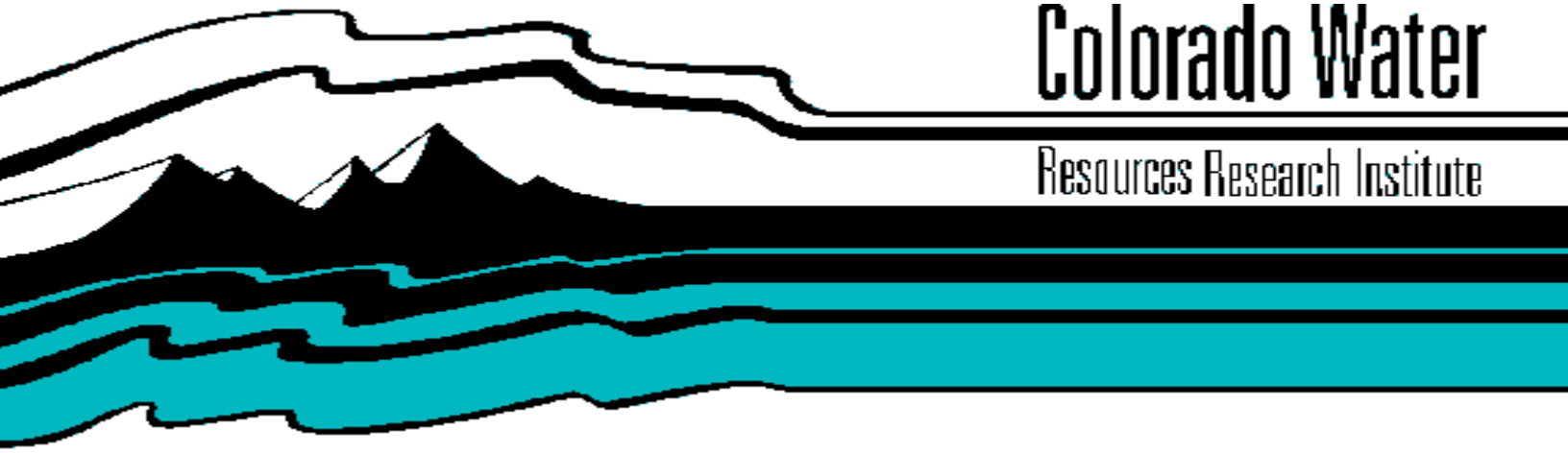
Seeking an Integrated Approach to Watershed Management in the South Platte Basin

Proceedings of the 1993 South Platte Forum
October 27-28, 1993



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Seeking an Integrated Approach to Watershed Management in the South Platte Basin

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Preface

This year's South Platte Forum attempted to define an integrated approach to watershed management in the South Platte River Basin. Scientists, engineers, attorneys, public administrators, farmers, students and many others spent two days relating experiences, presenting ideas, and sharing opinions on an integrated approach to management of the South Platte River. Based on feedback received from the conference attendees, the consensus on what approach to take was: no consensus! The need for an integrated approach was well supported, however, implementation needs to be defined. Competing demands for a limited water supply, and the escalating costs for "business as usual" approaches, are driving the interest in a more coordinated, integrated type of management.

Because integrated resource management incorporates, by definition, a wide range of resource management interests, this year's conference agenda was diverse. The 1993 South Platte Forum included over 37 presentations on topics ranging from agricultural water use efficiency to Congressional reauthorization of the Clean Water Act. Panel discussions addressed topics such as alternative dispute resolution methods, federal and states role in encouraging integrated watershed management, and problems associated with such an approach.

These Proceedings are compiled to provide the reader with a reference on the 1993 South Platte Forum - and to summarize some of the valuable insights that it brought forward. For specific questions about the presentations, please contact the individual authors. We have also provided a list of references for those interested in further reading. We thank all of you that helped make this year's Forum a successful and thought-provoking event!

Kathleen C. Klein, Editor
Robert C. Ward, CWRRI

Keynote Speakers

Using Water Naturally*

Dr. Holmes Rolston III

Department of Philosophy, Colorado State University

Many of you anticipated hearing the Governor speak this morning and it must be some disappointment to hear philosophy instead. Unfortunately, we could not get Dick Lamm to speak either, who was both Governor and philosopher. I will have to do the best that I can. I want to ask about using water naturally. One theme at this conference is using an integrative approach. I am contending that until we use water naturally we will be unable to achieve a completely integrative approach. Water is a part of the natural systems of the planet that we inhabit.

I want to think about using water ethically as well; about the ways we ought to use water. Anyone who has had introductory philosophy will know that the ethical and the natural can sometimes be a dangerous mix. One might think that using water ethically has nothing to do with whether we use water naturally. However, that may not be the case.

There are various interpretations of the word "natural." In one sense, everything that humans do is natural and we are unable to break the laws of nature. By that account, logically there could be no such thing as using water unnaturally, because everything that people do is part of the natural systems. There is another sense in which, when we humans deliberately modify natural systems, we have done something unnatural by virtue of intentionally interrupting otherwise spontaneous natural systems. In that sense, all human uses of water will have to be considered unnatural, because all actions, such as constructing ditch lines, modify wild nature. By that account, all of our uses of water are in some sense unnatural.

However, here is a third sense in which we can speak about using water naturally. We must consider the degree to which human activities fit in with the natural cycles of water in the ecosystems of the landscapes that we inhabit. In this sense, some uses of water might be more, some less, natural. I want to address this relative sense of using water naturally.

How do we use water at present? First, look at what Colorado water law does. It defines, through the Prior Appropriation Doctrine, the way in which we use water. The first people who obtained the water have a permanent right to use it thereafter, though we have also modified this in ways that I consider later. The idea behind our basic approach is that the first people who acquire water have a permanent right to it. I do not find anything particularly natural about that. However, there is a lot to be said for seniority. I have grey hair and my seniority is pretty high. There is a lot to be said for the idea of first-come, first-served. We think that there are certain kinds of properties of which the original finders are the keepers. All of our property rights go back to the idea that the people who first obtained a particular piece of property have the right to it thereafter. There is something to be said for seniority and for the first people who discover something as having a right to it.

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* **A longer paper is Holmes Rolston, III, "Using Water Naturally," Western Water Policy Project, Discussion Series Paper No. 9, Natural Resources Law Center, University of Colorado School of Law, Boulder, 1991.**

But it also may be that water is not that kind of a public good. We cannot just say that water is something that is once found and kept thereafter, because water is a kind of good that moves around, that flows over the landscape. We don't think that seniors can keep things forever; they retire, or die, and somebody else comes to take their jobs, or to use what was once their land and property. Common goods have to recycle, generation after generation, and even season after season, even day after day. Water is one of the fundamental natural givens, like air, soil, and sunshine. At least with air and sunshine we do not really think that these are the kinds of things that people find and keep. Perhaps, though, soil and water are.

We should notice that, so far as most of us here are concerned, we were not really first; our ancestors were just the first Europeans who came here, and found, and thought they could keep, the water. That helps us begin to worry a bit about this background idea that the water is something that the first people who found it have the right to keep. This idea may not fit too well with the natural way that water works on the landscape. The native Americans did not think of it that way. Water, like air, sunshine, and soil, is not something to be grabbed up by the first Europeans to arrive.

Another point to consider is that all the really prior appropriators are now dead. Anyone who established a water right in 1876 has long since departed. Prior appropriation was a way of obtaining water once upon a time. Rights have been inherited, but they have also often been sold. Now, water operates in the market. We use water economically and the prior appropriation scheme is just the historical background, the way, once upon time, we got water on the market. Now we say that whoever has money can buy the water. We want to use water economically. Water is, after all, a resource.

But then again, water may not be the kind of resource that we can simply put on the market, and let people buy and do with what they please. Many resources are left to user preferences. We do not think that we ought to tell people what to do with what they own. It is up to them to make the best use of their resources. The idea of a free market in a free country contains the idea that everyone can satisfy their own preferences as best they can. If you have money to buy water you can do with it what you please. However, again, water is a very basic good, like air, soil, sunshine, and may not be the kind of good that those who have the money can do with as they please.

Why not? Because perhaps markets do not attend to all of the values that are attached to water. If we are going to take an integrative view we must think more about the system of which water is so vital a part. Even on the economic side, we do have to notice that the people who appropriate water do not pay anything for the water where they take it up. They just take it as a natural given, something that falls from the skies and runs down the creeks and streams by gravity. Water is an ecological good, not an economic one at the point of intake. It's a natural given, not something manufactured. So even the appropriators are taking up a natural common good.

Notice, too, that a lot of the water systems have been heavily subsidized by the federal government. Therefore, we cannot simply say that everything that has happened to water has been a matter of market forces; to some extent it has been a matter of larger public policy. In any case, many of the values that are carried by water may not show up in the market system as well as we might think. There is an old saying that water flows uphill toward money. But I wonder whether, if water flows naturally downhill in the ecosystem, and if the economic system says that water flows uphill to money, we may be in for trouble.

How might we want to think about using water, in addition to economically? We are going to have to use water ecosystemically. We should think of water in terms of the hydrology of the watershed, of the bioregion, and even of the planet. There are many goods in the world that we do not put on the market. Such goods have to be handled in other ways in our public policy. We do not buy or sell children; we do not buy or sell votes. (Well, we ought not to, remember, this is a philosopher speaking, not the Governor). We doubt whether sex ought to bought and sold. We doubt whether wildlife ought to be bought and sold. We constrain markets to conserve endangered species. And to some extent we may doubt whether some of the values attached to water ought to be bought and sold because water belongs in a bigger ecological and planetary system.

Let's look at an illustration that depicts this on videotape. You can see moisture rising from the oceans, forming clouds, clouds drifting over mountains, rain falling. There is runoff gathering into streamlet and creeks, and on down the river. But, surprise, there is a city, and somebody taking a shower, somebody else flushing a toilet. And there is the water going down the drain; there's the sewage plant, and the water goes back into the river, and on down toward the sea. And back round again. Now we see that the water cycles in our homes, in the city, on the farm have to be little cycles inside much bigger ecosystemic and hydrological cycles. Now of course a video like this is childish and does not teach anyone here anything that you do not already know. But let's think philosophically about this. With people in the system, we have little cycles within the big cycles.

You just saw why we need integrative management. The water we use is a part of natural systems and unless our integrative management uses this water naturally in the sense of the big cycles containing the little cycles we don't have integrative management; we are not using water naturally. We are thinking about water more and more in terms of ecosystem management, more and more in terms of the hydrology of the planet that we inhabit. Already we are a long ways from finders keepers and the doctrine of prior appropriation as the only way to think of water. And we see that, if we market water, this has to be done so as to keep the little human circle inside the big ecological circle.

Let's come at this from the other side. What might be ways of using water unnaturally?

(1) If we were to use water in such a way that soil is destroyed, we would be using water unnaturally. That would be happening if the use of water was causing sedimentation, or causing erosion, or in some way cutting down our capacity in the soil to raise crops. Soil has been on the landscape a long period of time, water helps to form it. Soil holds water, and can support a sustainable water flow for thousands of years. But if our use of water is causing rapid erosion, that might be a flag that the water use is not fitting in with the soil capacities and fertilities of the system. This may be signaling some kind of a growth problem. Water use that destroys soil cuts down the scale during which a region can be inhabited from millennia to decades.

(2) Avoid water use that is not naturally sustainable. I fear that something unnatural may be happening in Colorado. When we mine our water, essentially we do not have a sustainable relationship with the hydrology. I am told that approximately 300,000 people in the state depend for their drinking water on nonreplenishable groundwater, essentially fossil water. You might say that we mine petroleum and coal, so why not mine water as well for irrigation and drinking water? My answer is that water is different from petroleum and coal because water is vital to our life system, our biology, in a way that petroleum and coal are not. If we consider building a culture on a landscape, if we plan for the long term future, we want our water to be the kind of thing that can

be coming for 100 years, even 500 years or 1000 years. You do not want to get into a relationship with the hydrology in which you depend on water that fell 10,000 years ago. Having squeezed all the water from a de-watered countryside, we proceed to mine it from the past. But maybe we don't want long-term dependencies of that kind.

(3) Big basin transfers might be unnatural, more or less in the degree to which they move water around from one landscape to another. Perhaps we do not want to become dependent on using water that comes from 1,000 miles away any more than we want to be dependent on water that fell on the earth 10,000 years ago. Of course, as we have said, water moves around naturally. The water that we have been drinking at our meal today fell a long way away. So there is nothing wrong with moving water around because, within the natural system water gets moved around in large amounts. What could be wrong with people moving water around?

Perhaps nothing, but what is likely to happen is that there will be a tendency to move the water so that it flows to the money, regardless of whether this is a good thing in relating people intelligently to their geography. If, in inter-basin transfers, the water flows to the money, this may be oblivious to the effects the subtracted water may have on the ecology in the basin from which it is taken. The water is likely to be taken from a well-watered region in the semi-arid west. The de-watered areas in that ecosystem are likely to contain a high proportion of biological riches in the landscape, the mammals, fishes, birds, amphibians, broad-leaved trees, the riparian floodplain floor and other things. Water is what keeps a landscape green, and selling one's native green environment is usually a bad bargain. On the uptake end, the place from which the water is taken is likely to be disrupted; and, on the outflow end, the place where the water goes is likely to be a crowded city that will be made bigger than it was before in a place that is already too dry to maintain the people who are there. Those kind of cities are already growing too rapidly, and once again the water, instead of flowing in ways that are relatively congenial to a geography, is simply flowing to the money.

The idea that one can obtain water where one wants it, and when one wants it can get to be too arrogant. *By God,* we want water right here, and if not *by God* then by human engineering. We will get water from however far away necessary to whomever needs it. That kind of mentality that is good up to a point; we make heroes out of our engineers and developers. But perhaps it can go too far, if it becomes imperialist, if all it has in mind is maximum exploitation, if it seeks the total management of water as opposed to attempting to merge a people's lifestyle with the natural hydrology of the system. Integrative management need not mean that we put water exactly where we want it, in whatever amounts we want, anywhere on the landscape, but rather that we intelligently fit ourselves in with the hydrology of a landscape. No city can have more water forever, and if not forever, why not begin to face the truth now. We need to know when to say enough, and to envision a steady state economy. The next hundred years of our city growth cannot be like the last hundred years.

(4) Avoid letting political boundaries ignore hydrology. Political boundaries that determine water use can be unnatural. A perfect example of a political boundary that ignores all geography is the outline of the state of Colorado, a big square about like the shape of this screen on which we showed the video. Does that look like a drainage basin? We have almost no political boundaries between the states in the West that follow the boundaries between watersheds. We are going to have to watch that the political boundaries we draw do not get in the way of using water naturally. I realize that management of water is often divided up into watersheds. We have already done a lot in terms of thinking about watersheds, but it is still true that with all our political boundaries we

ignore the hydrology. Political boundaries that ignore how two political communities are really one ecological community will generate conflicts of interest that serve political agendas and make people forget their sense of place. What watershed you are in is just as important as your voting district. The word "rival" goes back to the Latin word for "river," people who drink from the same river.

(5) Economics that forgets ecology is unnatural. A lot in our economy cuts against worrying about whether political or other institutional boundaries follow water flows, because our uses of so many other natural resources, and so many of our other cultural activities, can ignore our regional boundaries. We drive cars made of ores and minerals that came from all over the world, the parts in which were manufactured in a dozen nations. Our clothes come from China. You work for IBM and the hardware, the software, the financing that keeps the company going travels freely across state lines. If you are a member of the Presbyterian Church, the church does not pay all that much attention to the political boundaries. When you don't have to think about such boundaries, they don't make much difference.

However, when you deal with water it is not like shopping at K-Mart, or working for IBM, or belonging to the church because (remember our video illustration), you are dealing with something that is a little cycle in the big cycle. Water, then, may have to pay attention to geography in a way that much else in the economy does not. Let me say again that we move things around a great deal. I eat bananas every morning and I always notice where they come from because they have little stickers on them that identify the country of origin. I think: What a marvel it is that they come from Ecuador or Costa Rica. So why not import water from the other side of the continental divide?

Well, if not from too far away, I will not object. But once again, as with mined coal and petroleum, my answer is that water is a fundamental ecosystemic good in a way that bananas are not. I can get along without bananas, but I can't get along without a regular flow of water. It is just as important as air and sunshine. Just as mining water which fell 10,000 years ago, importing water which fell 1,000 miles away also signals a chronic growth problem rather than just progress in moving our resources around. I like to keep my lifelines short, and reasonably natural. Otherwise I create dependencies that I may come to regret.

(6) Do not degrade water quality. It is revealing that in the beginning our ancestors simply worried about water quantity; nature took care of the water quality. You could drink from any mountain stream. But now, water legislation has been forced increasingly to consider water quality. If the water does not have enough quality, it may be bad not only for the people but also for the ecosystem. The water has to be of a high enough quality to keep the system healthy. Toxics and pollutants in the streams and in the groundwater choke up the system. So legislation increasingly constrains the quantity of water that users take with the quality of the water that must be returned to the system. Worrying about this is a part of the picture of using water naturally.

(7) Another way of using water unnaturally asks about wildlife and endangered species, about biodiversity. If you subtract too much water from the system then the fauna and the flora are affected adversely. I mentioned that many of you may have been expecting to hear from the Governor this morning and while I am not the governor, I am making front page news. Or, more accurately, the ideas that I am talking about are right here on the front page of the Coloradoan. Here is a news story about the need to increase water flows to protect endangered species (October 27, 1993). When the farmers built the Joe Wright Reservoir in the 1900's they did not think at all about any impact on the pallid sturgeons over 500 miles down stream in eastern Nebraska. Today,

those who now have rights that go back to the Prior Appropriation Doctrine are finding that in the exercise of these rights they must consider the downstream picture of the effects that our subtractions from the system are having on wildlife habitat and endangered species.

In general, we are using water unnaturally unless we have an integrative policy that somehow says that ecosystem integrity overrides the economic development. You may not like that, but it has to do with your health and prosperity, in the larger sense. What that means, in terms of the picture you saw, is that the little circles running around the houses in the cities have got to be inside the big circles of the hydrology of the system. Maybe, once upon a time, we did not have to worry about that when we were smaller and our uses of water were different. But increasingly, as we face a new century, we can no longer ignore them. We have still got to fit the natural system we inhabit.

Let me close by turning from the front pages of the newspaper to thinking more philosophically. You may think of water as an economic resource; you may think that the first people who acquire the water have rights to use it -- they can buy, sell and so forth. This philosopher wants to remind you that water is one of the miracles of natural history. The planet that we inhabit is called Earth but in a way it really should be called Aqua because 70% of the surface is water. Earth is the only planet in the solar system in which there is a long history of liquid water flowing in large quantities, propelled by the energies of sunshine and recycled by currents of air. This water is put to remarkable use in biological systems. There is no other planet like that in our solar system and there may not be another planet like that anywhere in the universe. Water is the most vital resource on the planet; it is more than a resource, it is the life blood of the planet. Life was first conceived in the water, and water has been vital to life ever since. The rivers of water are part of a bigger philosophical picture, the rivers of life on earth. Unless we use water at least relatively naturally, we will mess all that natural history up, messing ourselves up with it.

Dogen, one of the medieval Zen Buddhists, used to drink from a bridge that still remains, built over a stream in front of Eiheiji, a mountain temple in Japan. The bridge is called the Half Dipper Bridge because Dogen would take a dipper full of water from the stream but only drink half of it. The other half he would pour back, rejoicing in its onward flow. You may be disappointed that you came to hear Roy Romer and are left with a Zen sage. I don't really think that water managers can derive water law in Colorado from a Zen sage. But there is an important insight about that half dipper model, one that can give some useful general orientation. Dogen sets an example of taking enough and fitting one's own life in harmoniously with the water flowing around us and through us over the millennia. Using water naturally in that sense does seem more profound philosophically, ecologically, and ethically than dewatering the river by rights purchased from those who took it by prior appropriation, all such water users with maximum exploitation in mind.

Legal Issues Associated With an Integrated Watershed Management Approach

Judge Robert Behrman

Division I

It is really a pleasure to be here today. I see a number of familiar faces that we see in our water court in Greeley from time to time. I am sorry that I wasn't able to join you yesterday. Particularly because I gathered that there was a discussion between Ms. Bates and Mr. Raley that ties into my subject. I have been conducting a bit of research on my own and I have just returned to court. It is a matter of some interest to me of why the State of Hawaii is the only western state that does not have the Prior Appropriations system. I went over there to check up on that. I am sorry to say that the folks on the beach didn't know either. In any event, I wish that I could have been there. In the program that I received, this is denoted as a keynote speech. In political conventions you rally the cause and you tell the attenders that only hard work is necessary to bring the party to a successful electoral conclusion. I am sorry to say that my talk today is the reverse of that. My general theme will be that the existing water law is not, in my opinion, conducive to an integrative approach to watershed management. I am a judge and I am not a legislator, so I am talking about "what is" in my view and not perhaps "what should be." Incidently, what I plan on doing is talking for approximately fifteen minutes and then if there are some questions, which I hope that there will be, I will be glad to respond to them.

I think the basic problem, from a legal point of view, of an integrated water management is that the laws concerning water are not themselves integrated. We have basically in the South Platte River two systems of law which govern matters. We have the federal law and the state law. The federal law is superior; by virtue of the Constitution of the United States takes precedence over state law. There is really no integrated federal water law. There is no United States water code of any nature and the matters covering water are scattered through a great many acts. The Clean Water Act, the Endangered Species Act, the Wild and Scenic River Act, and others are all cover water in a piecemeal basis. I must admit that our court does not have too many federal cases, although the United States occasionally has to litigate in our court, as was true recently. I think that they don't particularly care for that, although we try to be fair to all concerned. I really say that seriously because at my bench we have the flag of the United States as well as the flag of the State of Colorado and I try to remember that.

In any event, the federal law is not an integrated body of law and it seems to me that the federal agencies who administer these laws do not take what is, in my mind, an integrative approach in there own fields. This was brought home to me in the Reserved Rights case that we had concerning the National Forest. This was one of the cases in which the United States litigated in our court. One of the main issues was stream channel maintenance and the United States Forest Service presented very interesting evidence on the point and in the course of the evidence pointed out methods that they thought were examples of exactly how channel maintenance should not be attempted. There examples all involved the work of the United States Army Corp of Engineers. It seems to be that it is not possible to have integration even under federal law when the federal agencies are each out after their own ends. I don't think that this perspective is particularly susceptible to application to an integrated watershed management. Now federal law is superior, but it is less unified than state law. The federal law general covers instream matters, matters of supply

and so forth. The distribution of water is primarily within a state, not only within Colorado but the national pattern, is the subject of state law. States generally are charged with the responsibility and have under their sovereign authority the ability to administer and to govern the distribution of water within their borders. Here, in Colorado, the law finds its basis in the Constitution of the State of Colorado and there are two sections that are particularly important. I will read them:

> Article 16 Section 5: "the water of every natural stream, not here before appropriated within the state of Colorado is hereby declared to be the property of the public and the same is dedicated to the use of the people of the state, subject to appropriation that is herein after provided."

That does not sound too bad from the point of view of a basin-wide integrated management idea. The most quoted language from the Constitution of the State, heard over and over again and seen in Colorado Supreme Court decisions over and over again is "the right to divert the unappropriated waters of any natural stream to beneficial uses shall never be denied." That, of course, leads to an individualized approach to the withdrawal side of watershed management. The history has been, and what the statute appears to be aimed at, is a matter of individual initiative. Individuals, not only individuals in the sense of particular persons but also municipalities, water districts, irrigation companies, will be looking after their own interests and making appropriations as they see fit.

I might say that the language about the right to appropriate those waters is not to be denied is the strongest language in that regard in the Constitution of any state in the Union. Most western states have something similar to that but in every other case where they do have it there are some conditions, i.e. subject to public interest and all that. However, that is not present in the Colorado Constitution. Colorado is unique in that no permit is required before making a surface appropriation. The situation is somewhat different with wells, because well permits are required. There is no prior permit required to make an appropriation of surface water. Our theory is that it is made by initiating appropriation, which the court then does not grant the right to do that but confirms that it was done by a conditional decree. When that water is placed to beneficial use the court, again, does not permit the beneficial use but merely confirms that it has been put to beneficial use and recognizes that the decree is complete.

This whole system is aimed at a plan of individual addition. It seems to me that the whole scheme is not well-suited to a plan of integrated management, which in my mind involves some oversight which has not been present in Colorado law. I have played the Devil's Advocate for a little bit and I think that we have to admit that the results of that system have not been bad. As we look around we see one of the most fertile and productive agricultural regions in the entire country. That has been based on what has been done under this system. It has transformed what was essentially a semi-desert into one of the most productive agricultural regions of the United States. About 150 years ago when Hartman was retracing the Oregon Trail, I don't know how many of you are familiar with his book but he recites a situation where they were near the confluence of Cherry Creek and the South Platte River and wanted to water their horses but had to dig holes in the streambed to find any water. That area now supports a population of 2 million people or so. This system is not a failure.

In addition, there was a study made some years ago that I will bring up to a certain extent since I am playing Devil's Advocate. The study was of the Columbia River Basin, which is, if anything, an even more complicated basin than the South Platte. They studied whether there was any empirical

evidence, and there again the control is very fractured (there is no real unified control), that a unified control system would produce superior results to what was done under the system that existed, which is very similar to what is in existence here. Their conclusion was that there was no evidence that it would be. The unified system, by bringing in bureaucratic control, creates unanticipated results which are not all that favorable.

As I say, I don't think that our water law as presently constituted is favorable to unified control and that may or may not be a bad idea. I do think that this type of law may have been more applicable to a period when the question was development. Because there really is not that much surface water to be appropriated in the South Platte basin, the question is sustainability. I think we are seeing more and more cooperative schemes based not an any sort of legal feat but, by the persons concluding that their individual self interest is better served by cooperation than by competition.

We have a situation in which the cities of Thornton and Northglenn have an arrangement with the Farmer's Reservoir and Irrigation Company where pristine water belonging to the Farmer's Company goes through the city system and then the cities return the treated sewage effluent to the Farmer's Company for use in irrigation with a bonus of 10%. This is not to suggest that I think that all water is suitable for irrigation but I think there is a lot of water that is suitable for irrigation, but not for human consumption. I think that this is an approach that is developing as I say, on the basis of individual cooperation based on self-interest.

I think that this is the type of program that we are presently considering, although I can't discuss it in any detail because the matter is not completely resolved in our court, i.e. the program undertaken by the City of Thornton in the northern part of this county and Weld County. What they have proposed to do is, in essence, the same thing as they are doing with Farmer's but on a much larger scale; taking the pristine water to Thornton for use in their municipal system and then returning it to irrigation in this area. I think this may be a method that has further application and as this population grows and if we desire to maintain our agricultural economy it may be of increasing importance.

I think the future may be different than the past, but it is going to require legislation to bring about a situation that is more conducive to a unified approach to watershed management than has been true in the past. In the last presentation, Mr. Wright mentioned that he hoped that as this develops people would not overlook what has accrued in recreation along the South Platte corridor in Denver and surrounding areas. Similarly, I hope that if that occurs the benefits that have been achieved under our present system of water law will also not be overlooked.

Questions:

Question: I wonder, given the feeling that this law is not perhaps the best, if you had the ability to change it, what would you envision for a set of water laws?

Behrman: It does appear to me that the present situation breeds too much competition and it is expensive. Denver, itself has of course very adequate and fine water supply system. The newer communities around to a certain extent do not. There is intense competition between them as each one scratches for their own place. I think our present system tends to encourage that and it encourages the spending of a lot of money for legal matters, which I think is not all that great. The United States Forest Service case cost approximately 10 million dollars. I have heard estimates on

this Thornton case of about 4 million dollars. I think that those kind of expenditures are too large. I would hope that something in the order of what we call in law alternative dispute resolution, particularly in the scientific areas, could be applied. I don't think that our courtroom is the best way to iron out scientific disputes. Especially with a judge that perhaps does not understand all the nuances of what is going on. I would hope that a more cooperative approach could be adopted, but I am sorry to say that I cannot give a blueprint of it.

Question: Do you see a revision of the definition of beneficial use?

Behrman: In what regard? Because just about everything can be now.

Question: Isn't that the problem?

Behrman: It seems to me that one of the great benefits of our water law is that it is very responsive to changing facts and changing circumstances. I think what is beneficial use should be determined on the basis of what the situation is. What do you have in mind?

Question: Traditionally, irrigated agriculture has been seen as a beneficial use. There are many cases in which water is applied in excess of what is required and it still retains the definition of beneficial use.

Behrman: If the law is applied properly, it doesn't. Beneficial use, the Supreme Court has stated numerous times, does not include the right to waste water. I will agree with you that the practice is not entirely consistent with what the theory of the law is. In theory that is not the fault of the definition. I don't want to step on any of the State Engineer folks here but the problem may be in the way the law is enforced rather than the law itself. Wasteful uses are not considered beneficial uses.

Question: Why were water rights awarded to the structures instead of the applicants in the State of Colorado?

Behrman: Nice to see you again. Dr. Frisch has been one of our more ardent litigants in our court and I am sorry to say not one of the most satisfied. I can't really answer that. That is generally the pattern. We don't consider the matter of ownership in determining whether the water right has been perfected. That is generally handled in the regular district courts. But there are mechanisms, as I think you are in the process of finding out, for determining who owns the water right.

Question: Where do you see the US Forest Service current claim on the waters of some of our cities and irrigation companies – do you see a property scheme working out there, or are we looking at another lengthy court case?

Behrman: I must admit that I did not think the Forest Service took any particularly cooperative view in the Reserved Rights Case that we saw. It seemed to me that they were primarily pursuing their own interests and perhaps were not giving sufficient interest or consideration to the effects of these things on the population here. Of course of my decision, one of the grounds for my decision was that they have adequate regulatory power to protect their interests. I think that is coming home to roost. The extent of that regulatory power will be challenged in the court. It took one-half year of actual trial time spread over one and one-half years and a good many months of consideration for

me to figure out what the answer to the case I had was. I wouldn't venture to guess what the situation would be as to the limits, if any, on the regulatory power. I think that is the next case that is coming up.

Question: As water is attempted to be reallocated from senior rights to let's say threatened endangered species in Nebraska -- do you think these issues should go to our water court system?

Behrman: Well, I hope that it would be. But I am sorry to say I don't think that it necessarily has to be. I think they are approaching it through their regulatory power, and whereas the United States has to litigate matters of water distribution in a state court, that would be a question of the authority of the federal agency to make the regulations, and that would be determined in the federal courts and not in the state courts.

Question: Even though that reallocation could impact return flows?

Behrman: I think that comes down to the question of what limits there are, if any, of the regulatory powers of the federal agencies. I am sure that there are limits of that power but I don't think that anyone knows exactly what they are. I think that those matters will be determined in the federal, not state courts.

Question: This morning on the last talk, there were pictures of recreational uses of water in Denver. The pictures were to show that recreational and non-traditional uses could co-exist with the strict interpretation of the appropriation system. The point being that while recreation had no water rights, cooperation and management allowed those uses to occur. I think that they can occur with good faith efforts and integrative management. While I agree with all that you have said regarding the appropriation system, my feeling would be that the people here can work within that framework satisfactorily just as the Northglenn people did. It was difficult but it was cutting edge which laid the groundwork for Thornton. Thornton had an easier time than Northglenn did. I would say that they can coexist and be compatible; it is just a little more difficult here than it is in a trust state and Hawaii.

Behrman: I certainly hope that my remarks were not construed as being opposed to the appropriation system because I do not really think that for the arid regions, such as we live in, that anyone has come up with a satisfactory substitution for the appropriation system as a whole. As to the multiple uses, I do have an apartment in Denver and I do make use of those paths as a pedestrian. If there is some way that you can control the bicyclists that would be great because I have a constant fear of being hit by one.

Question: If the federal government tries to transfer water to threatened and endangered issues in Nebraska do you think that they should purchase the rights in Colorado, rather than use federal regulations to acquire them?

Behrman: I do not think that is a judicial question. You may suspect what I think but I don't think that I should draw any conclusions on that matter.

Seeking!

Robert C. Ward

Colorado Water Resources Research Institute

The theme of the 1993 South Platte Forum is "Seeking an Integrated Approach to Watershed Management in the South Platte River Basin". After having listened to the many speakers, representing many different dimensions of water management within a river basin, I am particularly struck at how very appropriate the word "seeking" is for the theme.

The new National Biological Survey, described at the Forum by Tom Muir, is an attempt by the Federal government to seek a new approach to management of the country's biological resources. The USGS's National Water Quality Assessment program, described by Kevin Dennehy, seeks to develop a much stronger data base for integrated watershed decision making. The Denver Water Board's new long range planning process, as described by Dave Little, is seeking new ways of defining the Board's future directions. The Colorado River Headwater's Forum, as presented by Doug Kemper, seeks to develop new formats for conflict resolution. The Rocky Mountain Farmers Union, as presented by Bill Thompson, seeks a state water policy. And the courts in Colorado, as discussed by Judge Robert Behrman, are seeking guidance in how to address the many emerging legal issues that surround a more integrated approach to water management. These are just of few of the many talks that described new efforts to seek an integrated approach to water management in the South Platte River basin.

Holmes Rolston, an environmental philosopher at Colorado State University, describes the need for the above changes in the context of a society that has just gone through the most remarkable century of development the world has ever seen, or will ever see again. The development activities of this remarkable century, Holmes argues, are not sustainable from a world ecosystem viewpoint. This is requiring society to shift from a development orientation to a sustainable orientation in its behavior. What we heard at this year's South Platte Forum was a society attempting to make that change. It won't come easy nor quickly, but it is beginning. The huge natural resource management "ship" is beginning to change directions and there is a lot of creaking involved.

While we see agencies and organizations within the South Platte basin seeking new approaches to watershed management, we also see Congress seeking to reauthorize the Clean Water Act, the Safe Drinking Water Act, and Superfund and Endangered Species legislation. We see universities facing the fact that many of their natural resource educational programs are oriented around narrow disciplines that emerged during the "development" century. They are now seeking ways to educate students in a more integrated manner and, yet, not lose the in-depth knowledge that will be needed to confront and solve future, complex water problems.

Thus, I walk away from the South Platte Forum this year feeling that change is being accepted in the way we manage water in Colorado; however, there is still a tremendous amount of work to be done in determining exactly how this change will occur in a fair and equitable manner. It is a very exciting time to be involved in Colorado's water management system, but it is also a time that will require the very best from all of us as we seek a more sustainable basis for managing Colorado's water in the future.

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Technical Papers Presented

Denver Water's Long-Range Planning Process

Steve Schmitzer and Jay Britton

Denver Water

ABSTRACT

George Santayana wrote, "those who cannot remember the past are condemned to repeat it." The Two Forks process and veto is history. Its demise has created an opportunity to develop a new approach for meeting future water demands in Denver's service area. Denver will not take the lead in water development to meet demands outside its service area. However, after Denver has assured itself that there are adequate supply options to meet supply commitments within its service area, Denver will consider how to optimize the supply system to assist other entities in the Denver Metro area.

Denver has entered a Long-Range Planning Process which will allow evaluation and comparison of all water supply options (including demand management) and their environmental impacts. The process will be open to various people and agencies interested in Denver's actions. The first step in the process is to revise Denver's system hydrology model to allow for detailed evaluations of supply options to meet demands. This model will be developed with public input and be made available to the public for its use. The second step will be to develop an environmental and hydrologic data base compatible with federal and state agencies. The third step will be to link the data base and the system hydrology model using a geographic information system (GIS), thus creating a comprehensive tool which can display results in an understandable format for making decisions.

It is essential throughout the Long-Range Planning Process to have participation by the general public, water suppliers within the region, environmental representatives, and federal and state agencies. Denver hopes that by involving the affected community early on, and by developing a public tool for assisting in the decision- making process, the best options can be identified to meet future demand for Denver and the Metro area.

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Ecosystem Management- A Process for Improving Watersheds?

Gary A. McVicker

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ABSTRACT

The new concept of ecosystem management is being widely adopted by both state and federal natural resource agencies. Although ecosystem management is still very much in its infancy, even in those agencies which have officially adopted it, the growing interest and participation by agencies, elected officials, public interest groups, and land users seems to point to a broad and fundamental shift in natural resource management philosophy and practice. While the title "ecosystem management" may imply primarily an orientation to environmental concerns, the concept potentially offers solutions to other long standing problems, including more effective management of the West's water resources.

Moving ecosystem management from concept to practice involves merging environmental, economic, social, and cultural values through a process of collaborative decision making on a landscape scale. Science becomes much more involved by providing input to decision making, analyzing the results of those decisions, and supporting continued education for improving the management of natural systems while supporting human welfare.

The human species must be considered a member of the ecosystem if the concept is to succeed, and restoring a "sense of community" with each other and with the land is viewed by many as fundamental to its practice. These community relationships may best be attained by focusing on watersheds as principal management units. Watersheds, unlike many ecosystems, are clearly definable in terms of geography and function and are integral to many human uses and activities. Watersheds therefore represent land units that a wide variety of publics, and public and private entities, can better identify with. Understanding and relating watershed functions will provide a catalyst for managing individual activities in the community interest.

Benefits accruing from well managed watersheds (e.g. functional riparian systems, reduced reservoir sedimentation, clean water, etc.) serve both as utilitarian and environmental objectives, such as biodiversity and ecosystem health, can also be fostered through this watershed/human interface.

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Example of Watershed Management, Lower Cherry Creek

Carmine Iadarola and Steve Boand

Aquasan Network, Inc.

ABSTRACT

Cherry Creek basin is an important component of the economic, environmental and quality of life in the Denver Metropolitan Area. It provides municipal water for 12 municipal providers, as well as business, agriculture, recreation, wetlands and unique plant and animal life. Often these uses conflict; however, maintaining and sustaining the integrity of each use is critical to the community. Diverting water for municipal use, while jeopardizing the Cherry Creek Reservoir or environmental integrity of the stream could have detrimental effects on the value of property, tax base, and attractiveness of the area.

Cherry Creek Valley Water and Sanitation District is located within the basin. Cherry Creek is an important source of recreation and enjoyment for the District's citizens and neighbors. The District needs to develop additional new water supplies for its buildout. The District Board determined that they could not appropriate new water supplies in other basins in good conscience until they were confident that they had effectively used the supplies in their own basin. An aggressive water conservation program addresses part of the District's needs; however, new water supplies will apparently need to be developed.

In this regard, the District invested heavily in developing a water model of the Cherry Creek Basin from Franktown to the confluence with the South Platte. The model provided valuable data about where, when, and how water is available in the Creek. It also demonstrated that with management and cooperation, most of the water needs in the Creek, both diversion and in-stream, could be fulfilled.

In this regard, Cherry Creek Valley has been working with Denver Water, Glendale State Parks, and several other users on the Creek during the past nine months to develop a management plan on the lower Cherry Creek. This process has provided a myriad of both positive and negative experiences, and has helped provide empirical data regarding real life encounters in trying to develop a cooperative approach to water management. It has helped bring to light the opportunities and challenges of watershed management.

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South Platte Water Conservation Project

Jon Altenhofen

Northern Colorado Water Conservancy District

ABSTRACT

The South Platte Water Conservation Project, as proposed by the Northern Colorado Water Conservancy District, is a multi-purpose project intended to divert unappropriated water and other waters lawfully available for diversion at the confluence of the South Platte and the Cache la Poudre Rivers. Through Project operations and a series of intra-ditch and river exchanges, that water will be "repositioned" higher in the Cache la Poudre River Basin for a variety of beneficial uses. The Project includes a forebay reservoir and pump station directly north of the confluence of the Cache la Poudre River and the South Platte River, a pipeline extending north from the confluence to McGrew Reservoir, a recharge project to utilize the Spring Creek, Lone Tree Creek, and Owl Creek Aquifers in the area east and north of the town of Pierce. The project includes the use of three existing storage reservoirs.

The mechanism that drives Project operations is the method of intra-ditch exchanges with large irrigation companies serving lands north of the Cache la Poudre River. Through these intra-ditch exchanges, water yielded from project operations is provided to these ditches for irrigation in exchange for the control for a similar quantity of water from sources that traditionally provided water to these companies, including direct flow decrees, reservoir storage rights, or Colorado-Big Thompson Project water. The higher quality water yielded from these intra-ditch exchanges is, in turn, exchanged through the Colorado-Big Thompson Project for beneficial use anywhere along the Front Range north of Broomfield. The project provides a wide range of water management alternatives as well as having many positive environmental aspects, including wetlands development and waterfowl and aquatic habitat enhancement.

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Managing Resources as an Integrated System

Stuart Simpson

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ABSTRACT

The Soil Conservation Service (SCS) has historically used an integrated watershed approach to soil and water conservation planning. SCS initiatives have included developing integrated watershed plans involving soil conservation land treatment, flood control, water quantity and water quality. A variety of state and federal programs have been utilized to provide technical and financial assistance to implement the plans that were developed. Such examples included the USDA Hydrologic Unit Area program, Rural Clean Water program, PL-566 Watershed Protection & Flood Prevention Program, 319 projects for water quality, and other state and local programs.

The planning processes used in the above initiatives includes the gathering of resource data, research that adequately demonstrates a problem, coalition building with potential sponsors, and organizing a method to implement both technical and financial assistance at the field level.

As an SCS program manager for water quality, I would like to share our processes in using the integrated approach to watershed planning. In doing so, I also believe that it is time to offer SCS assistance to accelerate integrated watershed planning. I believe that through integrated watershed planning, the South Platte River basin can have accelerated resource management applied through existing local delivery systems.

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Integrated Approach to Managing Multiple Basin Municipal Water Supplies

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ABSTRACT

This paper summarizes the results of a study that the City of Greeley recently completed for the development of a system to manage its water supplies. The City of Greeley owns water supplies in the Big Thompson basin, Cache la Poudre basin and from the Colorado River Basin, through the Colorado Big Thompson and Windy Gap projects. Historically, the City has operated its system to meet the demands, but has not tried to optimize the use of these supplies nor had it closely evaluated the yield of the water supplies during drought conditions. The City undertook this project with the objective to (1) develop a water resource management system that will enable them to optimize the use of their current water supplies, particularly during drought conditions, and (2) provide a tool to evaluate new water supplies and compare increases in firm yield that are created from the various new water opportunities.

To accomplish these goals, the study developed concurrent droughts of various return frequencies in the three basins. From these design periods, models were developed to simulate overall water rights yields in the Poudre and Big Thompson basins and for the Colorado Big Thompson system. From these models, a potential yield of water rights owned by the City of Greeley were determined. A second model was then used to optimize the distribution of water through the City of Greeley's water supply system in order to meet municipal demands. This model simulated integrated operations of water supplies from the multiple basin sources.

The system of models that was developed provides an integrated management system for multibasin water supplies in the South Platte basin. The system can assist the City of Greeley in management of their water supplies to optimize its water resources to meet the demands. The system can quickly compare different operational scenarios to determine the most cost-effective and water-efficient management plans to meet their demands. The system can also compare firm yields of various potential supply sources in order to help the City make informed decisions about future water rights purchases.

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Segment 15 - A Unique Watershed on the South Platte River

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ABSTRACT

Watersheds are defined as networks of channels through which water always flows from a higher to a lower elevation. The perimeter of a watershed is called a divide. In watersheds, flow always increases as you journey downstream and there is an increase in stream order. If this is the case, then there is a considerable portion of the South Platte River that does not have the attributes of a watershed and should not be treated as such. Integrated management of and in the South Platte Basin must recognize the uniqueness of the features of Segment 15. Attempts should not be made to apply models, concepts, comparisons, loads, and laws designed for "natural" systems to this segment of the river. If we wish to manage this resource as an integrated system, we first must recognize it for what it is, and not try and make it conform to what our steroptype of a watershed is. Direction given by water management groups, Congress, urban and agricultural water owners/users, outdoor recreationists, and government agencies must be tempered with the knowledge that this watershed(?) is unique. During most of the year, a good portion of the water in Segment 15 comes from west of the Continental Divide and crosses watershed boundaries as it is transmitted through tunnels, pipes, interceptors, pump stations, and reservoirs. The South Platte River dies and is reborn again through a modern wastewater treatment facility. Stream order for this segment is not defined by the number of tributaries connecting to the main connecting to the main channel, rather by the size of lines connecting to main interceptors. Flow, for the most part, is not determined by precipitation, rather by urban and agricultural usage and demand. Daily tidal flows, rather than seasonal flows, regulate the nutrient load of the river. Downstream irrigation diversions withdraw more water than is contributed by mainstem tributaries. In seeking an integrated approach to watershed management in the South Platte Basin, we must not forget it is not a natural river or watershed.

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Water Management and Endangered Species Protection of the South Platte River Basin

Tom Pitts

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ABSTRACT

Following issuance of a jeopardy opinion on the Narrows Project in 1983, the U.S. Fish and Wildlife Service and U.S. Bureau of Reclamation established the Platte River Management Joint Study to resolve outstanding issues regarding construction of the Narrows Project and endangered species protection on the Platte River in Central Nebraska. At the request of water users in Colorado, Wyoming, and Nebraska, this effort was expanded in 1984 to address all potential conflicts between water development and management in the Platte River Basin and endangered species protection in the Big Bend area of the Platte River. The Platte River Coordinating Committee, consisting of the U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, and the States of Colorado, Wyoming, and Nebraska was established in March, 1985. Water Users and environmental organizations also participate in the effort. The objective of this Committee is to engage in discussions to resolve conflicts in a manner that is consistent with interstate compacts, U.S. Supreme Court decrees, and State water law, while complying with the Federal Endangered Species Act.

The Coordinating Committee established technical committees to address a broad number of hydrologic and biological issues associated with water management and endangered species protection. Various reports were produced describing the hydrology and sediment transport capacity of the Platte River. The Biology Committee developed a recommended habitat plan that calls for development of 29,000 acres of habitat in an 89 mile reach of the Platte River in central Nebraska that includes designated critical habitat for the whooping crane. The technical plan did not identify the institutional or financial mechanisms for plan implementation, or the issue of how consistency with State water law, interstate compacts, and Supreme Court decrees allocating water would be achieved.

Beginning in December, 1993, the Joint Study began development of a Platte River Habitat Conservation Program. This draft Program recommends institutional mechanisms financial arrangements, and the manner in which Section 7 consultations under the Endangered Species Act would be carried out on water projects in the Platte River Basin. All Parties to the Joint Study are reviewing the draft Program and engaging in discussion of issues associated with program implementation.

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Initiating a Decision Support System for the Platte River Basin

Darrell G. Fontane

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ABSTRACT

Allocation of Platte River water within Colorado and between the Platte basin states of Colorado, Wyoming, and Nebraska is a topic of continuing controversy and expense. Recent years of drought and the relicensing process of the Nebraska McConaughy projects have only increased the stress on the river for irrigation, water supply, hydropower, and habitat. Much effort has been expended by each state and by several federal agencies to develop computer models for their particular interest - either for part of the basin or for an agency mission, such as water quality (Environmental Protection Agency).

Cooperation between the states is essential for the future efficient and wise use of Platte River water. Problems in individual states, such as water rights reallocation in Colorado and instream flow issues in Wyoming affect the water resources of Nebraska. Likewise, inefficient use of water in Nebraska means upstream states have less to use. A unified approach towards basin research is needed to effectively use limited research funds, and results must be ultimately aimed at decision makers who are responsible for water allocation policies.

The scope of the research will cover the Platte River basin of Colorado, Wyoming, and Nebraska. The objective of the research is to identify all the necessary components of a mathematical model of the Platte River Basin. The results will be used to 1) show a positive product of cooperation between the Basin Universities, 2) demonstrate what the requirements are for a model that would allow ecological and socioeconomic impact analysis, and 3) support the ongoing efforts of funding a more comprehensive proposal to develop a comprehensive Decision Support System.

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Threats to Biodiversity of the South Platte River by Exotic Plant Encroachment

Ron Broda

Weld County Pest and Weed Department

ABSTRACT

The presentation I would like to give is on the importance of native plant communities in maintaining a healthy and diverse ecosystem.

Riparian sites are some of the most biologically diverse and productive ecosystems in the Rocky Mountain region. What is happening along the South Platte River is that the native plant community is being replaced by non-native exotic plant species. Single species stands are being established along stretches of the South Platte River.

I wish to alert the various natural resource managers that would be attending this symposium of the significant vegetative and wildlife changes that are occurring along the South Platte River.

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River Habitat Selection of Waterfowl Wintering in Segment 15 of the South Platte River, Adams County, Colorado

G.D. Johnson, D.P. Young, Jr., W.P. Erickson, M.D. Strickland, and L.L. McDonald

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ABSTRACT

Segment 15 of the South Platte River downstream of the Metro Wastewater Reclamation District Central Plant is heavily used by waterfowl, especially during winter when other bodies of water are frozen. Dissolved oxygen (DO) levels in the river downstream of the treatment plant are currently below existing U.S. Environmental Protection Agency stream standards. Several river channel modifications are being proposed by the Metro Wastewater Reclamation District to increase DO levels in the South Platte River. Proposed river channel modifications may result in a change in river characteristics. We evaluated river habitat selection of waterfowl wintering in the South Platte River below the Metro Wastewater Reclamation District Central Plant to determine potential effects of proposed river channel modifications. Twelve waterfowl surveys were conducted in January and February 1993 on twenty 100-m river intervals and two large pools within the 10 km study area. Resource selection models were used to determine if a habitat type was selected more than expected based on its availability. Habitat types examined were large pools; secondary channels; and pools, runs, riffles, islands and sandbars within primary and secondary channels. The proportion of each habitat occurring within sampling intervals was estimated each survey, and waterfowl within each habitat were counted by species. Daily mean number of waterfowl was 711 per km of river over the entire study area. Nineteen species of waterfowl were observed in the study area. Individual species comprising over 5% of the population were, in order of abundance, northern shoveler, gadwall, mallard, northern pintail, green-winged teal, ring-necked duck, common goldeneye, and American wigeon. Habitat selection indices indicated that Canada geese used all habitats in proportion to their availability. As a group, dabbling ducks selected for large pools, secondary channels, riffles and sandbars; avoided smaller pools and islands; and used runs in proportion to their availability. Diving ducks selected for large pools, small pools, and runs; and avoided secondary channels, riffles, sandbars, and islands. Due to different and oftentimes opposing habitat preferences between diving and dabbling ducks, changes that alter river habitat structure in the South Platte River may increase use of the river by some species and decrease use by others. Based on differences in habitat selection between species, the best way to maintain diversity and abundance of waterfowl wintering in the South Platte River is to maintain a wide variety of habitat types.

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Modeling Land Surface-Atmospheric Interactions in the South Platte River Basin

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ABSTRACT

High elevation aquatic ecosystems of the southern Rocky Mountains and regional hydrologic dynamics in the South Platte Basin are expected to be modified by globally-forced changes in climate. Increasing concentrations of atmospheric trace gases may alter air temperatures, and precipitation patterns, amount, and intensity. Changes in these climatic parameters will directly affect the amount of snow, timing of snowmelt, and sources and seasonal distribution of atmospheric moisture, and seasonal availability of soil moisture. Indirect changes in hydrologic and biogeochemical patterns will be brought about as vegetation responds to climate change through changes in community structure and migration of communities up- or downslope. We are exploring how climate changes may affect hydrologic and terrestrial processes for the South Platte River Basin within a coupled simulation model-GIS environment, RHESSys (Regional HydroEcosystem Simulation System). Because land surface fluxes of water, energy, and CO_2 are intimately linked to mesoscale atmospheric processes, we are exploring the two-way interactions between land surface (hydrologic and ecosystem) processes and atmospheric processes. Abundant data and previous work available

from the South Platte River Basin allows us to test these linkages through coupled simulations of RHESSys with RAMS, the Colorado State University Regional Atmospheric Modeling System.

Uncoupled RAMS and RHESSys runs show that basin biogeochemical and hydrologic processes are sensitive to altered climate, and that regional climate is, in turn, sensitive to changes in land surface processes. Specifically, our initial results show that the climate of the Rocky Mountains and adjacent Great Plains is responsive to land surface characteristics, including vegetation type and location, and the juxtaposition of irrigated and non-irrigated land. We have also seen that hydrologic processes are sensitive to temperature and moisture. Fully-linked runs to understand the coupled response of hydrologic, ecosystem, and atmospheric processes are planned over the next 3 years. One of our goals is to bracket the potential range of changes expected in hydrologic, land surface, and climatic responses to different climate change scenarios to provide information to land managers. We will summarize our results to date within a land management context.

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Impacts of Water Transfers on Formerly Irrigated Lands in South Park

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ABSTRACT

Transfers of water rights from agricultural and industrial uses has occurred for many years in Colorado. These transfers have been particularly significant in the high-altitude stream basins of the upper South Platte, where approximately 20,250 ha (50,000 acres) of haylands were irrigated prior to the beginning of large-scale transfers initiated in the late 1960's. Only a small fraction of the acreage is currently being irrigated. The transfer of water has imposed significant changes in both the landscape and the land use pattrerns in this region.

From the standpoint of the landscape, water transfers have brought about changes in vegetation composition, seasonal plant productivity, and soils of the formerly irrigated meadows. Similarly, the nature of land use in hay meadows and riparian zones within these meadows has undergone transition. Previously irrigated meadows and riparian zones are now being grazed during the summer. Public access to streams for fishing has also increased substantially in recent years due to activities of the Colorado Division of Wildlife. These changes have greatly altered the economic and social structure of the South Park region. The objective of this presentation is to describe some of these changes and project some of their impacts on the region.

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Comparison Between Biomonitoring Methods for Benthic Invertebrates in Low-Gradient Sandy Reaches of the South Platte River

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ABSTRACT

Biomonotoring in low-gradient sandy-bottom streams has not been fully addressed. Most biomonitoring methods for benthic invertebrate sample collection and data analyses are for high-gradient cobble-bottom streams. A research project, supplementary to biological sampling of the U.S. Geological Survey's National Water Quality Assessment (NAWQA) program in the South Platte River basin, is comparing benthic invertebrate communities from different habitats using several collection methods. Invertebrates were collected in the Summer of 1993, using the NAWQA program protocols in two types of habitats: (1) richest targeted habitat (commonly submerged woody debris or rocks) and (2) depositional targeted habitat (commonly sandy). Invertebrates were also collected using methods based on the U.S. Environmental Protection Agency's rapid bioassessment protocols in substrates representing three major habitats: (1) submerged woody debris; (2) rocks: and (3) sandy substrates of the main channel. One objective is to determine the variability of benthic invertebrate communities inhabiting different substrates in the sandy reaches of the South Platte River. A second objective is to evaluate several metrics (standard measurements such as number of individuals, number of taxa, percent composition, etc.) from the invertebrate data. These metrics will be analyzed to evaluate whether invertebrate data can be used to distinguish between sites having different water quality in the South Platte River.

Several methods for collecting benthic invertebrates are currently used in the sandy reaches of the South Platte River. Consequently, the ability to compare and integrate results is limited. Results of this research might provide information useful for sampling benthic invertebrates in sandy reaches of the South Platte Basin and other sandy-bottom streams in the semi-arid West. This information might improve the understanding of: (1) variability of invertebrate data related to sampling method; (2) variability of invertebrate data related to habitat; and (3) selection of substrates for future biomonotoring studies.

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Channel Rehabilitation for Water Quality Improvement

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ABSTRACT

The reach of the South Platte River included in this investigation extends from the approximate downstream municipal limit of the City of Denver, near the Sand Creek confluence, downstream for approximately 40 kilometers (km) to a point near Fort Lupton, Colorado. This reach is referred to as Segment 15. The Metro Wastewater Reclamation District treatment facility, located immediately upstream of Sand Creek, has a capacity of 185 million gallons per day (mgd), approximately 8.1 cubic meters per second (cms). Studies to determine in-plant improvements and associated costs to meet more stringent effluent requirements using conventional wastewater treatment have been completed. The 1989 estimated costs associated with these improvements range from $70 million to $112 million. Massive in-plant construction may not solve other water quality problems along Segment 15; therefore, non-traditional alternatives such as instream reaeration, wetland construction, river modifications, water reuse/water exchange, dilution, and land-based treatment methods are being examined.

Extreme manipulation of basin hydrology by reservoir construction to enhance water supply, transmountain diversion into the basin, and by urbanization has occurred since the mid-1800's. During the same period, watershed changes and gravel mining has reduced sediment supply. Channel incision has resulted due to increased discharge and reduced sediment supply.

In an effort to protect infrastructure, dams and grade control structures have been constructed along the channel. Low dissolved oxygen, particularity during late-summer low flow periods, resulted in the backwater areas of the diversion dams and grade control structures. One of the most severe problems was found at 88th Avenue, the location of a grade control structure constructed in 1987 with a drop height of approximately 3 meters (m).

As a design alternative for consideration, the assumption was made that the water quality could be improved if the river was restored to a more natural combination of pools and riffles. The goal of the design alternative would be to maintain flood capacity and to improve esthetics, aquatic habitat, and dissolved oxygen. However, since about 1850 the drastic change in the basin has resulted in a metamorphosis of the South Platte River from a natural braided, intermittently flowing river to a sinuous, perennial river. Therefore, extensive studies were required to establish geomorphic and hydraulic rehabilitation criteria.

The presentation will outline the studies required to develop a design for channel rehabilitation which integrates the requirements of habitat, recreational boating, geomorphology, improved dissolved oxygen concentration, and channel stability. The presentation is an example of a positive

synergy between the Metro District, CDM, Inc., and Colorado State University to solve water quality and declining habitat problems that have resulted from over a hundred years of basin exploitation.

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Development of an Environmental Sustainability Index for Irrigated Agricultural Systems

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ABSTRACT

Integrated watershed management implies an understanding of the various land use sectors and their interrelationships. The agricultural sector is receiving increased attention as concerns heighten over water consumption and non-point source degradation of resources within a river basin. The current interest in sustainable agriculture is one evidence of this fact: for sustainability implies a productive agriculture existing in concert with other land-use sectors of a watershed or a river basin.

While qualitative discussions of sustainability abound in the literature, quantitative measures of the concept are practically non-existent. This paper presents the conceptual framework for the development of and environmental sustainability index for irrigated agricultural systems. The objective of the proposed index is to quantify, from an environmental perspective, the sustainability of irrigated agricultural systems.

A holistic approach is a prerequisite for tackling the issue of sustainability. A three-pronged framework of environmental sustainability indicators is proposed as the basis for the index: (i) indicators of inherent productivity of the system; (ii) indicators of the system's potential to degrade the surrounding environment, embodying the causes and potential for off-site environmental degradation through leaching and runoff, and; (iii) indicators of the ecosystem stability that will reflect the stability of the agricultural system from an ecosystem's perspective. The selection of various sustainability indicators within the aforementioned framework is outlined. Development of the testing and aggregation schemes, leading to the design of the overall index, is discussed. Anticipated results of application of the index are hypothesized.

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Origin and Fate of High Nitrate Concentrations in Water from the South Platte River Alluvial Aquifer-Preliminary Results

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U.S. Geological Survey,
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ABSTRACT

Data for the areal and vertical distribution of dissolved nitrate and related compounds in water from the South Platte River alluvial aquifer were used to determine the origin and fate of high nitrate concentrations in water from a part of the aquifer underlying an area of intensive irrigated agriculture between Platteville and Greeley, Colorado. Nitrate concentrations at the water table varied areally from <0.5 to 47 milligrams per liter as nitrogen, and average nitrate concentrations were higher in aerobic water underlying agricultural fields (22.6 ± 12.3 milligrams per liter) than in anaerobic water underlying the river (6.2 ± 4.2 mg/L). There was no apparent relation between nitrate concentration and depth. Values of $\delta^{15}N$ for dissolved nitrate in aerobic water underlying fields (11.0 ± 2.3 per mil) were consistent with an animal-waste source for the nitrate. Heavier $\delta^{15}N$ values for dissolved nitrate in anaerobic water underlying the river (17.6 ± 2.1 per mil) and the lower nitrate concentrations in water underlying the river indicate that microbial denitrification in the anaerobic part of the aquifer lowered nitrate concentrations, leaving the residual nitrate enriched in ^{15}N prior to ground-water discharge to the river. Further evidence for microbial denitrification in the aquifer included a buildup of N_2 and N_2O gases, both products of dentrification, in anaerobic water from the aquifer. These results may have important consequences for agricultural nitrate-management practices and aquatic biological assessments in the study area.

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Regional Evaluation of the Alluvial Groundwater Quality of the South Platte Basin From Denver to Greeley, Colorado

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ABSTRACT

A regional water balance was simulated for the period 1950-1988 for the reach of the South Platte River from Denver to Greeley. This area includes a total of 259,100 acres in southeastern Weld County, of which 150,400 acres is overly alluvial material and 135,400 acres is irrigated cropland. The average annual inflow for the period simulated totaled 915,000 acre-feet and the average outflow totaled 922,000 acre-feet. Average precipitation and potential crop evapotranspiration for the study area totaled 178,000 and 288,00 acre-feet respectively. The annual crop water requirement for the study area supplied through the conjunctive use of groundwater and surface water, averaged 190,100 acre-feet. Average alluvial groundwater storage totaled 2.02 million acre-feet and experienced no appreciable change in storage for the 39 years studied.

Average groundwater nitrate - nitrogen (NO_3-N) concentrations have increased approximately 7.9 milligrams per liter from the mid 1950's to the late 1980's. For the same period, the area-weighted average increase was 8.2 mg/l NO_3-N. This increase in NO_3-N concentration is attributed to agricultural and other land use practices. The net area-weighted annual impact to the groundwater resource in the study area is 9.14 pounds per acre nitrate - nitrogen. This corresponds to an average annual increase in groundwater nitrate - nitrogen concentration of 0.25 milligrams per liter from 1958 - 1990.

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Point- and Nonpoint-Source Loads of Nutrients in the South Platte River Basin

David W. Litke

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ABSTRACT

The relative magnitude of point- and nonpoint-source loads of nutrients in streams is important to those attempting to manage these loads. Point-source loads are primarily contributed by discharges from wastewater treatment plants and industries, and were estimated for the South Platte River Basin at National Pollutant Discharge Elimination System permit sites using site-specific data where available and estimated nutrient concentrations elsewhere. Nonpoint-source loads to the land surface were estimated using county data on fertilizer and manure applications and using precipitation chemistry data. The difference between calculated stream loads and known upstream point-source loads often is assumed to be equivalent to the nonpoint-source load.

Nonpoint-source nitrogen loads to the land surface of the South Platte River Basin were estimated to be 292,000 tons, of which 132,000 tons was from fertilizer, 94,000 tons was from manure, and 66,000 tons was from wet and dry atmospheric deposition. Total point-source nitrogen loads are estimated to be less than 10,000 tons. The total nitrogen load transported in the South Platte River at Roscoe, Nebraska, during a median-flow year was estimated to be 6,300 tons. Therefore, most of the nitrogen load to the land surface of the Basin, therefore, was not transported in streams. A large part of the nitrogen load probably does not enter groundwater or surface water because it is taken up by plants or remains immobile in the unsaturated zone; that part of the load that does enter groundwater or surface water is decreased by processes such as denitrification in ground water and biologic uptake in surface water. Instream loads also are decreased by removal of water at ditch diversion points.

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Assessment of Ground-Water Quality in South Platte Alluvial Aquifer from Chatfield Reservoir to Brighton, Colorado

Mike Wireman, Kris Jensen, Tony Selle, and Bill Monson

U.S. EPA Region VIII

ABSTRACT

Existing ground-water quality data was obtained from analyses of samples collected from more than 500 wells developed in the South Platte alluvial aquifer from Chatfield Reservoir to Brighton. The data were obtained from a variety of private and government sources. All inorganic, radionuclide and field parameter data were entered into dBase IV files. The wells from which samples were obtained were plotted on a map of the South Platte alluvial aquifer. The data were analyzed to determine spatial and temporal trends of selected ground-water quality parameters.

This paper describes the results of this ground-water quality assessment study. The study had two primary objectives; to develop a methodology for obtaining and managing existing water-quality data and to use that data to assess ground-water quality. A tremendous amount of water-quality data exists for the South Platte alluvial aquifer. Once the data were entered into an appropriate three dimensional data base, it was analyzed in a number of ways. These analyses, along with selected geological information were used develop an understanding of spatial and temporal variations in ground-water quality.

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Denver Watershed Management Minutemen & Minutewomen

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ABSTRACT

Development of best management practices for urban pollution control from the City of Denver received a significant boost in the 1973-76 period. It was then that the citizenry was effectively brought into the overall effort of monitoring and correcting pollutant discharges to the South Platte River.

The methods used for citizen involvement included intensive water quality monitoring at key locations by the Colorado Department of Health, allowing body-contact sports in the river within Denver, and constructing a river bottom trail for hiking and walking. A constituency for good water quality was rapidly established which, in turn, created a volunteer army of "river water quality minutemen" up and down the river. A respect for the South Platte River was developed at both the local and state government levels. Implementation of comprehensive stream water quality standards immediately followed.

Improvement in the South Platte River water quality management through Denver has been significant during the last 20 years. Swimming and tubing at Confluence Park in 1993 is routine, while in 1973 such body-contact sports were prohibited.

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Innovative Technologies for Water Conservation in Irrigation Water Management

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ABSTRACT

As urban growth increases the need for potable water supplies in the South Platte River basin, agricultural water supplies become valuable as a source for industrial and domestic use, thus increasing competition between water owners, suppliers and consumers of irrigation water to support a diversity of uses. Conserving scarce basin water supplies through water conservation in agricultural irrigation, urban irrigation, and domestic and industrial use is a complex issue involving water law, generation of information data bases on consumptive water use in urban and agricultural irrigation and knowledge of the dynamics of the distribution and groundwater system. This paper describes a research program currently under way to generate information and techniques for assessing agricultural and urban irrigation water use efficiencies and the impact on river basin water supplies when water conserving practices are implemented.

The project is evaluating and applying remote sensing technology including satellite imagery for large scale basin water management. Remote sensed land cover classifications are used for determination of evapotranspiration and real time monitoring and control of irrigation scheduling and irrigation system deliveries.

The project will test the implementation of new water conservation technologies and strategies in a river basin containing traditional irrigated agriculture, rapidly expanding urban areas and surface/ground water resources impacted by agricultural and municipal chemical contamination and conversion from agricultural to municipal/industrial usage.

Some of the program activities include:

1. The application of remote sensed vegetation classifications for urban, perennial and annual wetlands and irrigated agriculture to GIS based evapotranspiration models/system delivery models using Penman Montieth combination equations for control and prediction of basin wide scheduling to meet irrigation water demands.

2. The use of satellite imagery and change detection techniques for evaluation of historic changes in agricultural water usage in river basins such as the Poudre River Basin, undergoing conversion from agricultural to urban usage patterns.

3. The use of GIS technologies and results from historic change detection to predict future

agricultural water consumption patterns for river basins undergoing conversion to urban usage and impacted by drought conditions.

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Demand Management, An Important Component of Integrated Watershed Management

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ABSTRACT

Municipal water conservation, or "demand management," will play an important role in integrated watershed management for Colorado. At the 1993 state water convention, an initial survey of Front Range water alternatives was presented, including five major categories, one of which was "municipal water conservation." Reauthorization of the Clean Water Act may require municipal water providers to submit conservation plans, and Colorado presently requires water conservation plans for cities with annual deliveries in excess of 2000 acre-feet to be submitted by 1996. While the regulatory framework for water conservation is coming into place, there is a growing need for more research into basic economic and engineering considerations of water conservation.

Water demand management, a more definitive term than "water conservation," can be defined as a system of procedures that help control demand for water at the point of use, including control over quantity and timing of water use, through the use of efficiency or curtailment measures. Efficiency measures are of primary interest, whereby equal utility or service provided by water is maintained, while actual water use is reduced.

Municipal water demand management can provide several types of benefits, including:

* Delay or elimination of future water supply projects;

* Savings in water and wastewater treatment costs (i.e., capitol and/or operating costs); and

* More flexible watershed management, by reducing necessary diversions.

Trends in water demand management include a shift from a short-term drought response emphasis to a long-term strategic emphasis and from a communications/education orientation to an engineering/management orientation. With the change in emphasis to more engineering and economic analysis, there is presently a need to synthesize the experience that has been gained in water management and generate basic data on exactly how water is used in the municipal sector. Key research needs include (as identified in "Urban Water Conservation: Research Needs and Priorities," American Water Works Association - Research Foundation):

* Residential end uses of water;

* Commercial and industrial end uses of water; and

* Uncertainties and risks associated with demand management.

Many water demand management research projects are already underway in Colorado. The

Colorado Water Resources Research Institute (CWRRI) is participating in an analysis of municipal water use patterns for Denver-area water utilities. This project was initiated by the late Dr. William Bruvold of Berkeley and has compiled ten years of municipal water consumption data for ten water districts, along with information on corresponding water rates and water conservation programs implemented. These data are presently available to interested researchers through CWRRI.

The Colorado Office of Water Conservation, within the Colorado Water Conservation Board, is presently sponsoring numerous municipal demand management research/demonstration products. The author is currently participating in one such project with the Colorado Northwest Council of Governments and the Town of Steamboat Springs. This project has two parts: the development of demand management model that will allow resort community water managers to test the effectiveness of various demand management measures for their system and a retrofit experiment where demand management measures were installed in one condominium building and water consumption data is compared with an "identical" control building.

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Evaluation of Surface Irrigation Systems near Greeley, Colorado

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ABSTRACT

Sustainable agriculture and the minimizing of negative impacts by agriculture on the environment, has been generating much interest lately. Particularly in northeastern Colorado, there are concerns that return flows from irrigated agriculture are a source of pollution to ground water and surface water. Excess irrigation water not stored in the root zone for beneficial crop use can result in deep percolation below the crop root zone or surface runoff. This excess water is free to transport fertilizers and pesticides to the ground water and surface water downstream of the irrigation, possibly contributing to the degradation of water quality.

In a study on sustainable agriculture by the Central Colorado Water Conservancy District of Greeley, Colorado and funded by the Environmental Protection Agency, a field team from Colorado State University conducted on-farm monitoring of irrigation water use and water quality. The monitoring study is helping to identify the pollution potential of current irrigation practices in the South Platte Basin.

The CSU team intensively monitored three surface fields during the summer of 1992 and 1993. A mass balance approach was used to quantify the water inputs to selected fields and the amount of water lost to deep percolation and surface runoff. The amount of water applied to individual fields and the amount of water running off were monitored. The quantity of water used by the plants was estimated using a reference evapotranspiration equation and weather data. The relative loss from deep percolation was calculated. Irrigation application efficiency, tail water ratio and deep percolation ratio were calculated. The nitrate level, of concern for health considerations, was regularly tested in the irrigation pump water and surface water.

The range of irrigation application efficiencies measured for the surface irrigated fields was surprisingly wide, ranging from 7% to 67%. The resulting deep percolation for the three fields indicates how leaching of nitrates to the ground water might be affected by this wide range of efficiencies. Although low application efficiencies suggest an opportunity to improve irrigation system performance and reduce nitrate leaching, downstream users of the South Platte River are dependant upon irrigation return flows for late season irrigation.

Further analyses of water use, water quality and transport processes of pollutants in the soil are needed to make recommendations regarding measures to improve ground water quality.

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Showcase for Sustainable Agriculture and Water Conservation: Integrated Fish and Plant Production at the Rocky Mountain Aquarium in Estes Park

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ABSTRACT

Like other states in the western U.S. with arid climates, Colorado receives less rain during the summer growing season than states in other regions. Other factors minimize opportunities for the production of both plants and animals during late autumn, winter, and early spring . Despite these liabilities, Colorado is a leader in many segments of agricultural production, due in large part to a generous supply of solar radiation, significant groundwater supplies, and a sophisticated collection and distribution system for snowmelt.

Aquaculture is the fastest growing segment of the U.S. agriculture economy. Traditional forms of aquaculture, however, are very dependant on large quantities of high-quality water. If the aquaculture industry is to expand significantly in Colorado, then the aquaculture techniques that conserve valuable resources such as water must built and brought into operation.

The Rocky Mountain Aquarium Foundation currently is developing an integrated fish and plant production pavilion as a part of the Rocky Mountain Aquarium complex in Estes Park, Colorado. The facility will be a showcase for sustainable agriculture and integrated fish and plant production, using state-of-the-art water recirculation production technology.

This paper presents the rationale and objectives for the development of this type of aquaculture facility and discusses anticipated outcomes, particularly with respect to water conservation education. The role of water recirculation fish production and its importance in the integration of fish and plant production is presented, with a focus on the use of fish production wastewater and other by-products as valuable resources.

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Other South Platte River Basin Research

Water Balance for Verification of Consumptive Use in the Cache la Poudre River Basin

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ABSTRACT

Many of the important water resources development issues facing the Western United States can be observed in the Cache la Poudre River basin of Northeastern Colorado. Because the Poudre River basin is one of the most intensively managed and studied basins in the west, it represents a unique large-scale laboratory for testing and evaluating new water management technologies. As part of a larger project to quantify water use, a total water balance is being developed for the entire Poudre basin. The purpose of the balance is to provide validation of a basin evapotranspiration model developed using remotely sensed imagery.

The major use of water in the basin has traditionally been for irrigated agriculture, but recent growth has led to the increased demand by municipal interests and a shift in water consumption from the traditional users. As these new water use trends take shape, new strategies must be developed for integrating the diverse demands on the limited water resource. Central to the implementation of any integrated management strategy is the identification of where existing water is going. The water balance being developed will identify all the major users of water in the basin and determine overall consumptive use in the basin. In addition, it will include balances on several sub-basin levels, including municipalities, and quantify consumptive use of these sub-basin units.

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Irrigated Farmers Use of Information Provided by Satellite

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ABSTRACT

Improved irrigation technology, advanced management practices, and communication systems offer an opportunity to use water more efficiently. During the 1993 irrigation season, Colorado State University Cooperative Extension implemented a model program to disseminate information daily to assist agricultural irrigators with improved water use practices. Every day throughout the growing season, irrigators could receive weather data summaries, crop water use and heat unit accumulation information for wheat, corn and beans via a KU band satellite system. More than 500 farmers in northeast Colorado have the ag information satellite system already in place on their farms and ranches. In addition, the systems can be found in many county extension offices, grain elevators, vo-ag classrooms, banks and local restaurants.

The project utilized information collected from remote sensing weather stations located at 18 different sites along or near the South Platte. The USDA Agricultural Research Service, Colorado Agricultural Meteorological System and the Northern Colorado Water Conservancy District (NCWCD) provided the real-time data, which CSU Cooperative Extension accessed and calculated evapotranspiration rates daily and accumulated heat units for crops at each of the sites being monitored in northeast Colorado.

Irrigation related information in the past had not been widely disseminated, and had limited access provided by radio stations and local newspapers, or accessed by modem from a bulletin board at the Northern Colorado Water Conservancy District (NCWCD) office in Loveland. Less than 100 irrigators utilized the modem to obtain the information in 1992. This model project has great potential for disseminating real-time data, in addition to providing educational information to irrigators along the South Platte at a relatively low cost. Expansion of the program is being considered for the 1994 crop growing season.

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Use of Geographic Information Systems in a Water-Quality Assessment Project

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ABSTRACT

A geographic information system (GIS) is being used to assist in the design and implementation of the U.S. Geological Survey National Water Quality Assessment Program (NAWQA) at the national- and the basin-study scale. Nation-wide data sets, such as hydrologic-unit boundaries, population density, crop types, physiographic provinces, and ecoregions, have been used to partition study units into homogeneous subareas for water-quality sampling. More spatially accurate versions of these data sets are being developed at the basin-study scale to evaluate the relation between water-quality data and available geographic data. In addition to geographic analysis, the GIS is useful for establishing a common database for individuals working on different aspects of the project. Spatial data can be displayed in a variety of ways, which enhances the flow of information and ideas between project personnel with different specialties.

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Aeration Performance Testing of Low Drop Weirs

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Abstract

Concerns for recreational boater safety and for migration of fish species limited the difference in water surface elevation to approximately 0.7 meters for a series of low drop grade control and aeration weirs anticipated for the South Platte River near Denver, Colorado. Review of existing aeration efficiency prediction relationships indicated that prototype-scale model studies, or actual prototype data, were limited in the range of drop heights and discharges required for the anticipated project. Most laboratory testing has been conducted at greater drop heights and lower unit discharges. To reduce experimental uncertainty associated with prototype-scale model flume aeration testing at low drop heights, a procedure was developed which uses an enhanced-oxygen atmosphere over the flume water surface. A conservative estimate of the uncertainty in the data developed from the testing procedure is 10% or less. Based on the testing, a new aeration efficiency prediction relationship was developed which is similar to the relationship of Avery and Novak (1978) and includes a dimensionless term to account for tailwater depth.

The presentation will demonstrate positive results of application of sound civil engineering research to water quality and habitat problems. The presentation will be of value in explaining the results of the flume testing and in demonstrating the unique capabilities of the CSU hydraulics laboratory which may applicable to other resource problems that are being studied by scientists who are not familiar with the capabilities of the laboratory. Integration of resource management requires that managers are aware of all the tools which can be at their disposal.

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Decision Support System for Conjunctive Stream-Aquifer Management in the South Platte Basin

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ABSTRACT

A micro-computer based decision support system has been prepared for conjunctive stream-aquifer management (DSS) through a synthesis of existing technology rather than development of new models. The finite difference groundwater model (MODRSP) was linked with a capacitated river basin network management model (MODSIM) using geographical information system (GIS) and database technology (DBMS).

The computer-aided design package, AUTOCAD, and a powerful, low-cost, raster GIS package, IDRISI, are used for preparing grid-based spatial data which is directly input into MODRSP, a modified version of the USGS three-dimensional finite difference groundwater model, MODFLOW, to generate numerical groundwater response coefficients. These response coefficients are used by MODSIM to simulate spatially varied and time-lagged stream-aquifer return/depletion flows.

The integration of GIS, DBMS, MODFLOW, and MODSIM allow analysis of conjunctive use plans which are capable of considering decreed flow and storage rights, river calls, exchanges, trades, and plans for augmentation. The groundwater hydrologic components modeled using MODSIM include reservoir seepage, irrigation infiltration, well pumping, and channel loss, channel routing, return flows, river depletion due to pumping, and aquifer storage.

A case study was carried out on a portion of the Lower South Platte River Basin, Colorado between Kersey and Balzac gage stations. A groundwater grid network was prepared using GIS techniques and response coefficients were generated using MODRSP. The coefficients were used in MODSIM to simulate the Bijou Augmentation Plan water right account. The effects of the Bijou Augmentation Plan on daily administration of the South Platte River Water District #1 by the Office of the State Engineer were simulated using MODSIM. Prototype user interfaces were prepared using the desktop mapping software, MapInfo, and the spreadsheet software, QUATTRO PRO, to demonstrate decision support system capabilities.

Computerized data available from databases maintained by the Colorado State Engineer (water rights, diversions, groundwater, stream flow); USGS (groundwater, digital line graphs, digital land use, digital elevation data, streamflow); and Bureau of Census (TIGER files) were used for the study.

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Development of a Reservoir Operations Model to Optimize Flood Control in Irrigation Reservoirs

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ABSTRACT

Irrigation reservoirs in the western United States often have no flood control responsibilities. These reservoirs are operated solely for the purpose of over-year and intraseason storage of water for irrigated purposes. These reservoirs can, however, provide some flood control storage without adversely affecting water yields for irrigation purposes.

These irrigation reservoirs are usually highly dependent upon snowpack runoff from filling during the spring runoff season. Prediction of reservoir inflow from snowmelt runoff generally has a component of risk associated with it which makes operation of an irrigation reservoir to include a flood control function difficult.

A procedure is developed to estimate the fractiles of the expected distribution of snowmelt inflow to a reservoir based on snow survey runoff forecasts. This procedure estimates the conditional probability of runoff amounts based on snow survey forecasts for March 1, April 1, and May 1. This procedure allows for the utilization of the reservoir for flood storage while minimizing the possible reduction in irrigation water yield.

The procedure is intended for practical application to the operation of reservoirs where limited inflow data may exist. The procedure is based on establishing confidence limits on the snow survey base forecast of inflow to a particular reservoir. An example is provided of application of this procedure to a major irrigation reservoir in Idaho.

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Distribution and Composition of Bed Sediment in the South Platte River Basin

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ABSTRACT

Bed sediment was collected from 17 sites in the South Platte River basin during low-flow periods in the summer of 1992. This basin-wide reconnaissance survey is part of the U.S. Geological Survey's National Water Quality Assessment (NAWQA) Program in the South Platte River Basin. Sites sampled included: seven streamflow gaging stations on the South Platte River; seven tributary sites; two reservoirs; and one irrigation ditch.

Particle-size analysis indicated decrease in the <2.00 millimeter size fraction in a downstream direction in the South Platte River. The bed sediment of the tributaries is more fine grained than the South Platte River bed sediment, and the irrigation ditch had the greatest amount of coarse-grained bed sediment (>0.063 millimeters) of all sites sampled. The particle size of bottom sediment in the reservoirs is similar to the particle size of bed sediment in the nearby tributaries, but bias may have been introduced by using an Ekman dredge to sample the reservoirs.

Bed-sediment samples also were collected and processed for analysis of selected organic constituents (<2.00 millimeters) and for selected trace elements (<0.063 millimeters). Results of chemical analyses are pending.

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Tailoring Requirements to Reality: The Santa Ana River Use Attainability Analysis

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ABSTRACT

This paper presents a summary of a comprehensive use attainability analysis (UAA) on the Santa Ana River in Southern California. The river is an urbanized effluent-dominated watercourse that has its origin in the foothills of the San Bernadino Mountains. The Santa Ana River has multiple beneficial uses including warm water aquatic life.

As a result of the river being placed on the EPA's 304(1) "short" list for presumed impairment of the aquatic life use because of heavy metals contamination, a year long UAA was conducted along its entire length. The UAA included integrated water chemistry, fish surveys, invertebrate enumeration, biomonitoring, habitat assessment, fish flesh analysis, pathogen screening, and socio-economic impact analysis.

The UAA found no impairment due to metals, but found physical habitat limitations and some impairment from chlorine, ammonia, and nitrate. Beneficial use modifications, site specific water quality objectives, and reach boundary changes were recommended. Two billion dollars in unnecessary capitol improvements were avoided. The project also provided a holistic picture of the Santa Ana River that is being used by policy-makers and utilities for future planning and informed decision-making.

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Integrated Management

Anita J. Nein

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ABSTRACT

Integrated management operates on a fundamental change that we can no longer look at our own individual businesses, farms, communities, or recreational needs through ordinary glasses; we need to look through binoculars or telescopes to see out and beyond to the needs of those around us as well. Thus, we strive to think in a multifaceted way and realize that the effects of any of our actions reach out to other parts of our operations and to other living things in our ecosystems as well. The philosophy in John 15: 5, written long ago, is relevant today as we think about a good approach to integrated management. "I am the Vine; you are the branches. Whoever lives in me and I in him shall produce a large crop of fruit. For apart from me you can't do a thing." So it is with integrated management, that none of us can be fruitful on our own any more. We need to grow mentally and spiritually to be able to realize that our individual rights are not worth much unless we are in harmony with the rest of our environment and with the community as it operates around and through us. We must take ownership of our individual and community problems, and capture action to change those problems.

The majority of farmers are already using an integrated approach. For example, in Sedgwick County, Merlyn Thrasher deals with several different entities in planning and carrying out total integrated resource management including cell range management, high residue use management, irrigation water management, and windbreak management for wildlife and erosion. He farms next to the river; helps in the recharge of the South Platte Aquifer; and practices wildlife management, nutrient management, integrated pest management, and energy use management. Merlyn lives in the small town of Julesburg, so he also sees the importance of water quality management, trash and waste management, limited space management, and watershed management in light of flood control. He is a participator in all of the major ecosystems of Sedgwick County, which are small towns, irrigated land, dry land, rangeland, and riparian land. He is also a part of a nonliving system important to integrated management, the educational system. Each of these systems has synergistic effects on items important to all of us, such as water quality, wildlife, energy, biodiversity, biochemical changes, soil quality, erosion levels, waste management, sustainability of resources, idea sharing, and quality of human life.

How do we get larger entities such as towns, agencies, governments, and the whole South Platte Basin to manage resources in an integrated way? All we have to do is fine tune, expand, and continue what we've already begun. Much productive work has already been done in many governmental entities, farms, ranches, cities, and towns. Therefore, continue to gather data, educate, and use better ways of applying practices. Explore new technology, work together, and look outward. Moreover, turn to ourselves for the solutions to our own collective problems.

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