Measuring Cost-Effectiveness of Environmental Water Transactions

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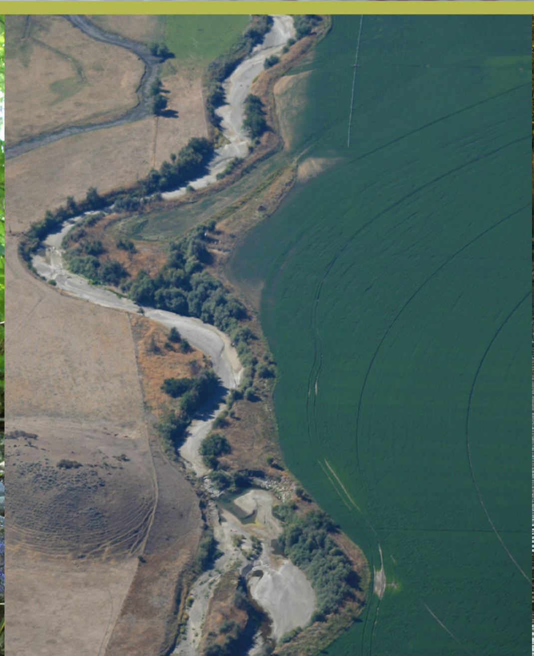

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Photography credits and captions for front and back cover are shown on page 82.

*Water use and crop acreage for 1998–2010: CA Department of Water Resources

EXECUTIVE SUMMARY

The diversion, storage and consumptive use of water in the western United States (US) has drastically altered streamflow, water quality and a raft of ecological, social and economic goods and services. Over the last fifty years, western states have begun to address this problem through a range of approaches. Water quality regulations, endangered species protections, application of the public trust doctrine to water allocations and other regulatory approaches reflect an effort to prevent further degradation of streamflow and associated values. For example, in Oregon, minimum streamflow requirements created in the 1950s were converted into full-fledged instream water rights in the 1980s and 1990s to limit further appropriations of water for out-of-stream use. Unfortunately, as junior (or low) priority rights, these rights do not serve to restore flow to already dewatered streams. In other cases, both large and small, regulatory enforcement has led to real improvements in water for the environment. In California, the protections afforded to Mono Lake water levels and the re-dedication of contract water to environmental uses under the Central Valley Project Improvement Act, are but two examples. However, the controversy, costs and lengthy timespan of dedicating water to the environment through litigation and regulatory approaches are unappealing to some conservation groups, particularly those that prefer to collaborate and purchase water rather than litigate to achieve streamflow restoration.

An alternative approach to meet streamflow restoration needs is to proactively negotiate in the "water market" for the acquisition of existing out-of-stream rights or for changes in water use and management in order to benefit the environment. These transactions result in "environmental flows," including the dedication or protection of water instream or the provision of water to consumptive environmental uses (such as for floodplain habitat). This suite of activities is referred to as "environmental water transactions." In California – where streamflow and freshwater ecosystems are as adversely impacted by water resource development as anywhere else in the country – this market-based approach to streamflow restoration has been slow to emerge as widespread practice. However, interest in this approach by conservation groups in California is increasing, particularly with the 2014 passage of the Proposition 1 Water Bond, which Which allocates $200 million dollars for stream flow enhancement, including environmental water transactions.

This report aims to provide context and methodological assistance on the cost-effectiveness of environmental water transactions (EWT) to the various groups that will be involved in this effort. In doing so, we draw on experience with these transactions from the Columbia Basin in the Pacific Northwest, and in states across the western US Specifically, this report aims to assist public funding agencies and project proponents to maximize the cost-effectiveness of investments in projects intended to enhance the quantity of environmental flows. The report provides discussion, guidance and recommendations on cost-effectiveness metrics for environmental water transactions. Detailed instructions for the use of a basic cost-effectiveness metric based on water volumes are laid out, along with an initial testing of the metric to a set of existing transaction data from the Whychus Creek watershed in the Deschutes Basin, Oregon.

CALIFORNIA ENVIRONMENTAL WATER TRANSACTION TOOLS

The report begins with an explanation of the potential types of environmental water transactions in the California context, including their relative advantages and disadvantages. This discussion is based on general experience with such transactions across the western US, extending these to the suite of transaction tools available under the California Water Code. Five environmental water transaction tools that can be used in California to increase environmental flows are covered:

1. Temporary environmental flow transfers under Section 1707 of the California Water Code.
2. Forbearance agreements, particularly short-term partial season agreements, which do not involve formal water right changes.
3. Long-term and permanent environmental flow transfers under Section 1707 of the California Water Code.
4. Water conservation projects (increases in water use efficiency) and subsequent dedication of conserved water to environmental flows under Section 1707 of the California Water Code.
5. Fee title acquisition of land and water rights or land conservation easements, and dedication of associated water rights, or portions thereof, to environmental flow.

For each EWT tool, this section described the basic mechanics, including basic legal and practical considerations, as well as key advantages and disadvantages. In addition to describing the tools and their relative pros and cons, this section discussed potential environmental flow benefits, water costs, transaction costs, and social/community dynamics for each tool. Figure ES-1 below shows a very approximate attempt to compare the six tools based on the discussion above. Each tool is placed on a spectrum from good/best to bad/worst for these four assessment areas.

The results suggest that tools with the highest potential flow benefits also come with potentially higher water and transaction costs, as well as potential for social/community opposition. The converse is also true. Often the tools with the lowest potential environmental benefits (in this case, primarily due to their lack of durability) also have the lowest prospective costs and risk of opposition. Another useful way to think about this general finding is to consider it from a programmatic perspective. The process of building an EWT program often involves early phase projects that have low costs and low risk of opposition under the theory that these projects help build trust in a community and help to build toward more high risk, high cost projects at more mature phases of programmatic development. As a consequence, early stage projects are likely to have lesser and short-term environmental benefits. The theory being that as time passes and the programs mature there will be a shift in transactions to those that have more significant and secure environmental benefits.

In sum, there are a number of tools available to practitioners in California. Each of the tools reviewed have distinct advantages in certain scenarios and drawbacks in others. California's complex and sometimes confusing legal framework for environmental transfers does not help to crystalize any clear overall "winner" among the analyzed EWT tools.

Figure ES-1: Comparative Analysis of Environmental Water Transaction Tools

Environmental Flow Benefits	Water Cost	Transaction Costs	Social / Community Dynamics
Lowest Flow Benefits	Lowest Cost	Lowest Cost	Lowest Risk of Opposition
Temporary Transfers	Short-term Partial Season Temporary Transfers	Short-term Partial Season Temporary Transfers	Short-term Partial Season
Conserved Water Long-term Transfers Short-term Partial Season Fallowing	Long-term Transfers Permanent Transfers Land/Water Purchase	Conserved Water Long-term Transfers Permanent Transfers	Temporary Transfers Conserved Water Land / Water Purchase
Land/Water Purchase Permanent Transfers	Conserved Water	Land/Water Purchase	Long-term Transfers Permanent Transfers
Highest Flow Benefits	Highest Cost	Highest Cost	Highest Risk of Opposition

MEASURING COST-EFFECTIVENESS OF ENVIRONMENTAL WATER TRANSACTIONS

The purpose and use of cost-effectiveness information is then discussed focusing on how each of the various groups involved in these transactions is likely to view the issue. The conclusion of this discussion is that there are a variety of reasons why a particular group might want cost-effectiveness information. It is probably most useful to start with the practitioner and work outward from there. In this regard, cost-effectiveness analysis is potentially a very useful tool for guiding practical planning and implementation of flow restoration programs. However it is important to realize that even at the field level, cost-effectiveness will never be the only reason to prefer one type of transaction versus another. There are other criteria that the practitioner—and all other participants—will be wise to heed in planning for success.

The report goes on to examine the choices that guide selection of cost and effectiveness metrics, as well as the combination of these into a cost-effectiveness metric. The conclusion is that cost-effectiveness metrics must be practical and replicable, able to be applied in the planning stages (i.e., before undertaking the transaction) and able to be applied on a transaction-by-transaction basis across a range of transactions. For this reason the paper offers a volumetric cost-effectiveness metric, in other words a dollars per acre-foot metric. However, the actual calculations must account for inflation, different term lengths for transactions and differing reliability between individual transactions (as shown in Figure ES-1). Thus, even this basic cost-effectiveness metric is involved, and a considerable amount of the report is spent developing the methods, examining whether practitioners currently collect or use such information, and carrying out an initial application of the approach to prove its workability.

Figure ES-2: A Basic Cost-Effectiveness Calculation Procedure

COST-EFFECTIVENESS (CE)

$$CE = \frac{\textit{Inflation Adjusted Cost (\$)}}{\textit{Wet Discounted EFlows (AF)}}$$

Transaction Water	Water Costs
↓	↓
Adjust to EFlows	Transaction Costs
↓	↓
Adjust to Wet Water	Total Costs
↓	↓
Discount Water	Adjust for Inflation
↓	↓
Total Wet Discounted EFlows	Inflation Adjusted Cost

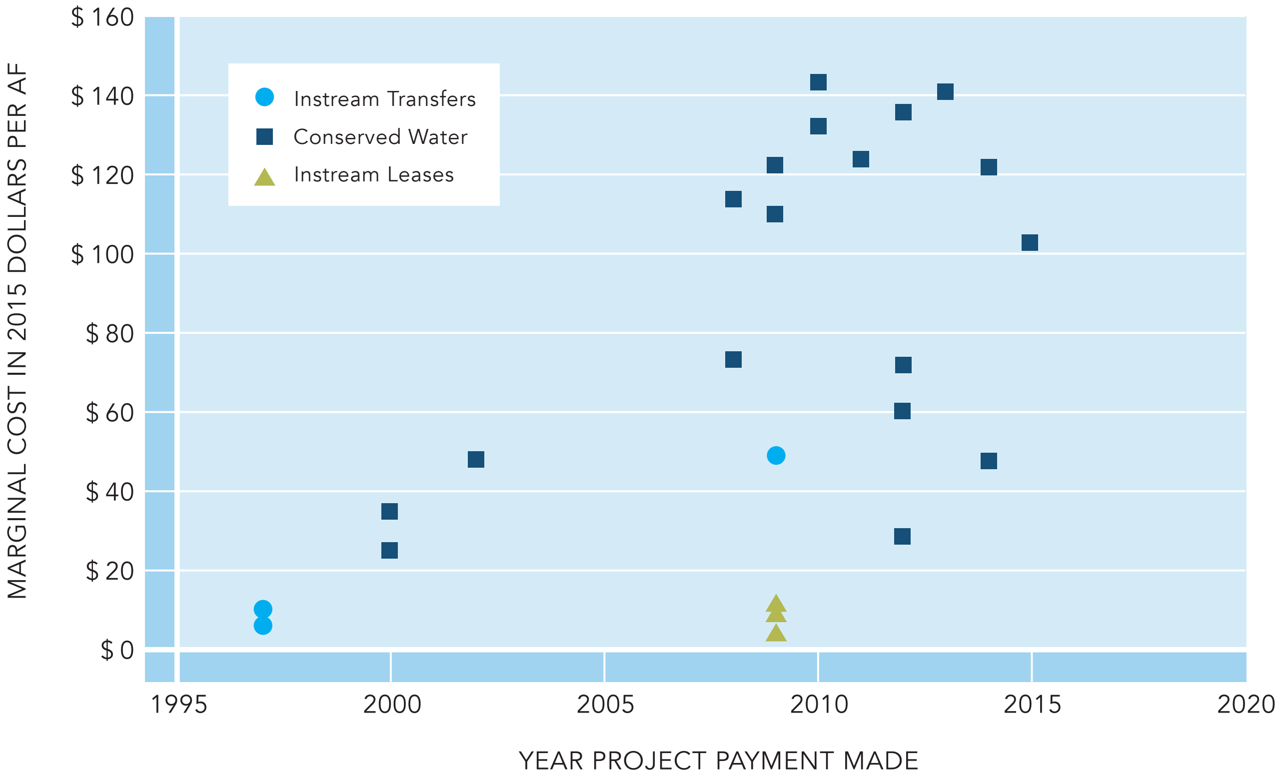
Other things equal, practitioners and their organizational leadership would probably want to pursue the least cost approach to flow restoration in a given reach or system. However, things are never equal and the decision of which transactions to pursue is, and should be, based not only on financial criteria but other ecological, social, funding, legal and administrative criteria emerging out of the local context in which transactions are designed and implemented.

Beyond the narrow confines of a particular reach or system are the larger and more complex questions of how an implementing organization or a funder chooses to allocate funds across different geographies. In these cases the basic volumetric cost-effectiveness indicators offers some information, but does not really convey the complexity of the effectiveness of various transactions in terms of their increment toward flow targets or towards habitat or ecological goals. In order to compare across distinct geographies, more advanced metrics are required. These metrics will be difficult to apply on a transaction-by-transaction basis but may be able to be applied on a reach basis or even on a programmatic basis. Even with such advanced metrics in hand, the problem of commensurability may still exist. How can an ecological restoration outcome in one system be compared with that in another? Is meeting a flow target of 5 cubic feet per second (cfs) in a creek at all comparable to that of achieving a 250 cfs flow in a river? How do you compare restoration of an extirpated population of Chinook salmon in one basin with the restoration of a population of Coho salmon in another basin?

The recommendation of the report is that it is better to walk first and run later. A survey administered to EWT practitioners across the western US shows that basic cost-effectiveness information as laid out in this report is not yet being prepared by most entities engaged in this field. Nor do most large public funding programs require this information. Therefore, the first step is to adopt and adapt the volumetric cost-effectiveness approach to the needs of the various entities engaged in environmental water transactions. Provision of the basic data necessary to carry out the cost-effectiveness calculations laid out in the report is a straightforward matter. If practitioners do not have the requisite information then it may assist them in their efforts to conduct strategic and cost-effective flow restoration programs to begin to collect and apply this information.

To demonstrate the feasibility of the recommended methods an initial application of the approach is made to the Whychus Creek watershed. Streamflow restoration in Whychus Creek is critical to the ongoing reintroduction of anadromous species to the upper Deschutes Basin. Data from almost twenty years of transactions representing the expenditure of almost $17 million and 35 cfs of water rights is compiled and analyzed in terms of cost-effectiveness. The transactions include instream transfers, the allocation of conserved water to instream use and instream leases. The results show a clear pattern of increasing cost over time and considerable dispersion of cost between types of transactions, with leases being the least expensive followed by transfers and then conserved water.

Figure ES-3: Cost-Effectiveness of Whychus Transactions over Time



Further efforts to apply these metrics in particular sites should help assess the robustness of the basic cost-effectiveness metrics and foster development of more advanced approaches that include cost-effectiveness metrics for progress towards flow targets and ecological outcomes. These efforts should provide further insight into best practice for data collection, management and reporting. In this regard it would be instrumental for public funders that run larger challenge grant programs or targeted funding program, such as the California Wildlife Conservation Board and Bonneville Power Administration's Columbia Basin Water Transaction Program to support this effort. In the long run such funders may wish to adopt a common set of standard data requirements for their grantees and to regularly produce cost-effectiveness data from funding applications received, approved and completed.

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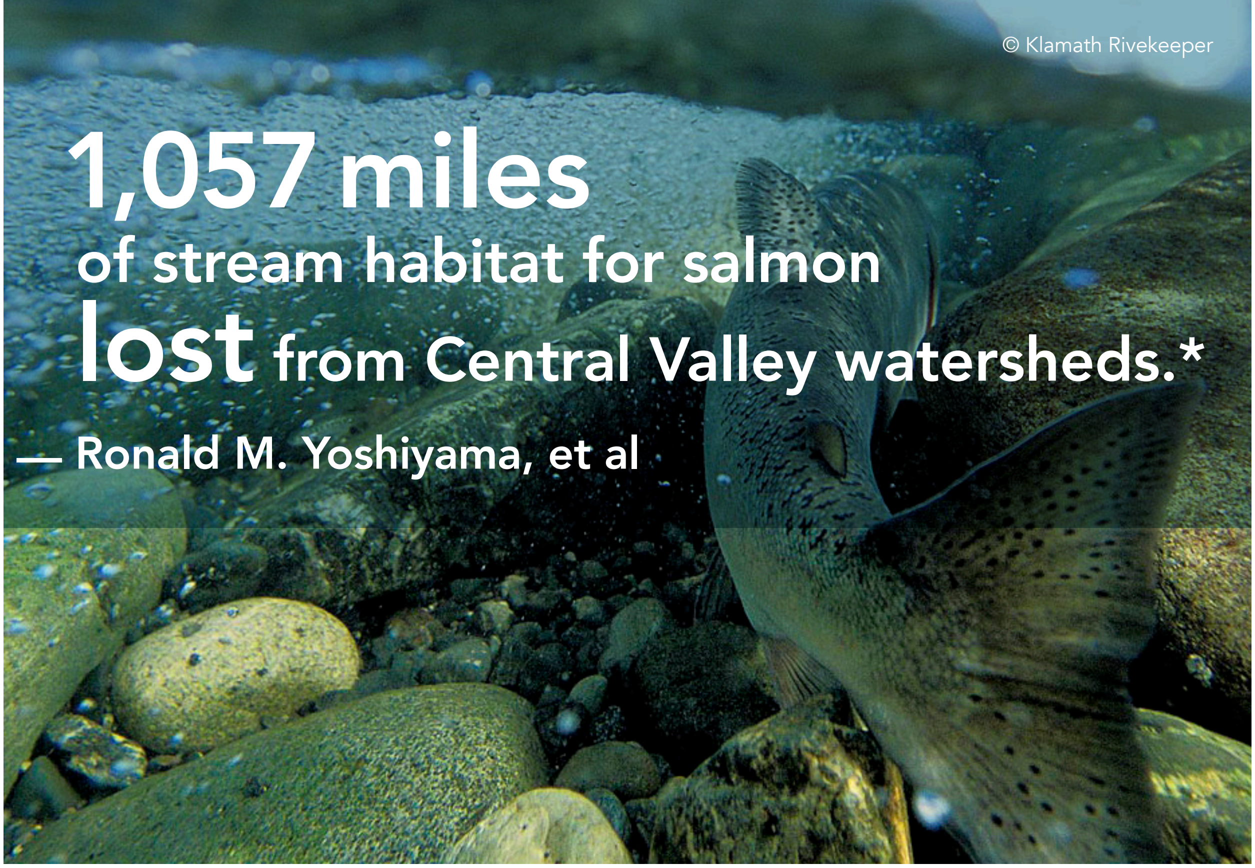

*Historical and Present Distribution of Chinook Salmon in the Central Valley Drainage of California
Ronald M. Yoshiyama, Eric R. Gerstung, Frank W. Fisher, and Peter B. Moyle

1. INTRODUCTION

The history of water resource development in the western United States (US) is one of developing water infrastructure to meet human needs for water, food, power and transport. The resulting storage, diversion and use of water over the last one hundred and fifty years has adversely affected streamflow, water quality and a raft of ecological, social and economic goods and services. Over the last fifty years, western states have begun to address this problem through a range of approaches. Many of these approaches can be considered as regulatory in nature, such as regulating water quality, protecting species, and applying the public trust doctrine to water allocations. Many of these approaches constitute an effort to play "defense" in order to prevent further degradation of streamflow and associated values. These efforts are often defensive in that they limit further appropriations of water for out-of-stream use. Unfortunately, as junior (or low) priority rights these rights do not serve to restore flow to already dewatered streams.

Playing "offense" is essential to restore streamflow and its associated values. Efforts to play "offense" through regulatory or judicial channels have seen occasional victories, such as the restoration of flows to Mono Lake in California and the dedication of contract water to environmental uses under the Central Valley Project Improvement Act, but these strategies face challenges in providing a consistent, predictable and comprehensive path to environmental flows given the strong property interest in water rights already vested and permitted by states.

An alternative approach to meet streamflow restoration needs is to proactively negotiate in the "water market" for the acquisition of existing out-of-stream rights or for changes in water use and management in order to benefit the environment. These will often result in the "instream" use of water and will generally be referenced herein as environmental uses or environmental flows, in order to incorporate consumptive environmental uses (such as for floodplain habitat). This suite of activities is increasingly called "environmental water transactions" (Aylward 2013b).

In California – where streamflow and freshwater ecosystems are as adversely impacted by water resource development as anywhere else in the country – this market-based approach to streamflow restoration has been slow to emerge as widespread practice. However, interest in this approach by conservation groups in California is picking up and the 2014 passage of the Proposition 1 Water Bond makes $200 million available for stream flow enhancement including environmental water transactions. This report aims to provide context and methodological assistance to the various groups that will be involved in this effort. In doing so, we draw on experience with these transactions from the Columbia Basin in the Pacific Northwest, and in states across the western U.S. Specifically, this report aims to assist public funding agencies and project proponents to maximize the cost-effectiveness of investments in projects intended to enhance the quantity of environmental flows.

The report begins with an explanation of the potential types of environmental water transactions in the California context, including their relative advantages and disadvantages. This discussion is based on general experience with such transactions across the western US. The purpose and use of cost-effectiveness information is then discussed focusing on how each of the various groups involved in these transactions is likely to view the issue. We then turn to separate discussions of cost and effectiveness metrics for environmental water transactions, before merging the discussion in order to propose basic and advanced cost-effectiveness metrics. The methods for calculating the basic water cost-effectiveness metric are then explained in detail. We then present results of a survey of practitioners aimed at better understanding what current practice is with regard to the collection, maintenance and use of cost-effectiveness data from transactions. In a final section an initial application of the basic cost-effectiveness metric to data from Whychus Creek in the Deschutes Basin of Oregon is provided. Conclusions and recommendations round out the report.

2. CALIFORNIA ENVIRONMENTAL WATER TRANSACTION TOOLS

Before developing a metric for cost-effectiveness of environmental water transactions (EWT), it is important to understand the mechanics of specific EWTs in California as well as some of the more general advantages and disadvantages of each of the tools. A wide range of approaches to classifying EWTs exist and there are an almost infinite array of variations on these transactions (See generally Aylward (2013a). With that in mind, this section discusses six different environmental water transaction tools that can be used in California to increase environmental flows to benefit aquatic habitat and species that rely on this habitat:

1. Temporary environmental flow transfers under Section 1707 of the California Water Code.
2. Forbearance agreements, particularly short-term partial season agreements, which do not involve formal water right changes.
3. Long-term and permanent environmental flow transfers under Section 1707 of the California Water Code.
4. Water conservation projects (increases in water use efficiency) and subsequent dedication of conserved water to environmental flows under Section 1707 of the California Water Code.
5. Fee title acquisition of land and water rights or land conservation easements, and dedication of associated water rights, or portions thereof, to environmental flow.

Each of these strategies represents a different combination of timing and acquisition/project mechanism, and as such, some overlap exists between some EWT tools. For each EWT tool, this section describes how the tool works, including basic legal and practical considerations, and then discusses key advantages and disadvantages of each tool. Specifically, for each tool this section discusses: potential environmental flow benefits, water costs, transaction costs, and social/community dynamics.

2.1 OVERVIEW OF SECTION 1707

California adopted Section 1707 of its water code in 1991. This brief section of the water code adds "preserving or enhancing wetland habitat, fish and wildlife resources, or recreation" to the list of reasons for applying for either a long-term (including permanent) or a short-term (one year or less) change (Cal. Water Code §1707(a)(1)). Instead of carving out separate pathways for these environmental water right changes, Section 1707 simply mandates that these changes, often referred to as instream dedications, go through existing water right change processes laid out in Sections 1725 (one year or less), 1735 (any period in excess of one year), and 1435 (temporary urgency changes up to 180 days). Section 1701 also provides for a change to be approved without a definitive end date. Upon approval of one of these water right changes, the dedication or use of water instream can be legally protected based on the priority date of the water right. In addition, under section 1011(b) of the California water code, conserved water (as the term is defined in the statute) can also be transferred under the same code sections as other water rights.

2.2 SHORT-TERM ENVIRONMENTAL FLOW TRANSFERS

Environmental flow transfers of one year or less (but not so-called "urgency " changes, mentioned briefly above) referred to in the California water code as "temporary" transfers, are subject to the review process outlined in Section 1725. Section 1725 allows changes to water rights, including the addition of environmental purposes, by petition to the State Water Resources Control Board (SWRCB). The SWRCB can make determinations on water right changes under Section 1725 without a public hearing and is statutorily exempt from California Environmental Quality Act (CEQA) review. While the water code does not require a hearing or CEQA analysis for temporary transfers, it does limit the amount of water that can be temporarily transferred to water that "would have been consumptively used" and that will not injure any legal user of the water (Cal. Water Code §1725). Even though temporary changes can be completed without a hearing or CEQA analysis, the SWRCB does consider any comments received in response to a publication of notice about each temporary transfer and comments can prompt the need for additional work on the part of applicants to demonstrate no injury and/or quantify historic consumptive use.

2.2.1 ADVANTAGES AND DISADVANTAGES

Regardless of their duration, transactions that derive their benefit from a reduction in consumptive use share a number of fundamental advantages and disadvantages (Aylward 2013c). The principal advantage is the ability to transfer the reduction in consumptive use to instream use for lasting benefit downstream in streams and rivers. The disadvantage can be that the injury and consumptive use analyses pose difficult, technical hydrologic questions. As a result, applicants for temporary changes in California may incur potentially significant transaction costs to quantify past consumptive use and make a showing of no injury.

The SWRCB places the burden of proof for showing that the transfer will not injure other water users on the applicant. In other western states such as Oregon, while the no injury rule is applied to temporary transfers, the state water resources agency undertakes the injury evaluation rather than requiring the applicant to do so.

The SWRCB likewise requires applicants to determine the amount of water that has been consumptively used and limits the transfer to this amount. Consumptive use is defined as water consumed by evapotranspiration, percolation underground, or has "otherwise been removed from the downstream water supply as a result of direct diversion"(Cal. Water Code § 1725). For similar temporary transfers in Oregon, the state water resources agency simply uses crop consumptive use values calculated generally for each of the states' major watersheds in quantifying the amount of water subject to transfer and for injury analysis. Using this simple estimate saves significant time and is justified by the temporary nature of the changes and also by the fact that Oregon law allows the state water resources agency to "undo" any temporary change that causes injury in fact.

On paper, California's temporary environmental transfer statute appears to offer a streamlined, expedited administrative process for simple temporary transfers. However, in practice, the tool has not been widely or successfully used for many environmental transfers. A recent study found that the average approval time of environmental transfers under section 1725 is over four months, despite the fact that these transfers are changes for one year or less (Szeptycki et al. 2015). As of April 2014, a total of only 15 temporary transfers had been approved since instream dedications became legal in 1991. Only two of these transfers were filed by small, private entities or NGOs and the remaining were filed by the Bureau of Reclamation or an irrigation district. (Szeptycki et al. 2015).

2.2.2 ENVIRONMENTAL FLOW BENEFIT

A major shortcoming of California's temporary transfer tool is that it is limited to one-year or less. Given the amount of effort that is required on the applicant's part to quantify consumptive use and show no injury, along with the observed lengthy processing times, the benefits in terms of environmental flow protection may not be worth the effort (as revealed by the limited application of this tool by non-profit organizations). By their nature, the benefits of short-term environmental transfers suffer from a lack of durability. By limiting these benefits to one year or less before requiring renewal, California makes short-term transfers even more untenable. One of the primary reasons that short term transfers are justifiable in other western states is because they generally enjoy expedited processing times and significant transaction cost savings that allow them to be a flexible tool, deployed with short notice to address existing as well as emerging flow issues. This has not been the case in California, and as a result, it is difficult to justify the short-term environmental flow benefits provided by this tool.

2.2.3 WATER COSTS

The amount that will need to be paid to the water user to lease their water right for environmental purposes is likely to be related to their opportunity cost, i.e., what the user gives up by entering into the lease and not using their water for a year. For irrigators engaged in farming or ranching as a livelihood activity, this amount will likely need to meet or exceed the net income derived from using the water in irrigation. For irrigators engaged more in lifestyle (or amenity) water uses, this amount will depend on the personal or social utility garnered from activity that the water use underlies (e.g., providing pasture for horses or other quasi-domesticated animal). If there is an active temporary market in annual water trades or rental of irrigated land then the opportunity cost may be benchmarked against these figures. Not surprisingly, the cost of such water can vary tremendously depending on location and other circumstances. In some cases, the value derived for either livelihood or lifestyle purpose is very low – the water is simply a cost center for a rural lot – and the amount that needs to be paid is minimal. In other cases, high value commercial farming or demand and supply in an accessible water market (such as in the Central Valley with state or federal water) may mean prices in the hundreds of dollars per acre-foot per year.

2.2.4 TRANSACTION COSTS

As discussed above, transaction costs for temporary transfers in California are high. Applicants are required to show that the change will not cause injury to other water users and are also required to quantify past consumptive use. The SWRCB leaves it to applicant to determine how to make this showing. Applicants are therefore free to use a simple mechanism, such as regional estimates of consumptive use supplied by UC Extension services, however doing so carries a risk of not standing up review on the occasion of a protest. If the applicant wants to undertake more in depth analyses to insure against potential challenges, then injury and consumptive use analyses will likely be time consuming and potentially expensive, even for small transactions. Further, even though temporary transfers are exempt from hearings and CEQA analysis, the need for the applicant to respond to comments on proposed changes further increases transaction costs. In a number of other western states, including Oregon, state water resources agencies are responsible for responding to comments, saving applicants time and money and potentially greatly reducing transaction costs overall. Given the restriction on temporary transfers to one year or less, combined with the burden placed on the applicant, it may be difficult to justify transaction costs required for temporary transfers in California.

2.2.5 SOCIAL/COMMUNITY DYNAMICS

Generally speaking, temporary transfers are some of the least likely EWT tools to incur significant community opposition. Temporary water right changes tend to be significantly less controversial than permanent or long-term changes because the perceived threat to the farming and irrigation lifestyle is much lower. As a result, temporary changes are often thought of as the best entry point for EWT efforts. The theory is that engaging in temporary changes can help build trust and dispel the notion that EWTs are always bad for a community. Once sufficient trust is built with a community, temporary transactions can lead to discussions of more durable transaction types. It is important to emphasize that while there are examples of this theory holding true in the real world, there are also examples where leasing simply begets more leasing, instead of leading to permanent transfers.

2.3 FORBEARANCE AGREEMENTS

In contrast to formal water right changes under Section 1707, forbearance agreements do not rely on approval by the SWRCB or any other state or federal agency. These agreements are simply private agreements between water right holders and another private entity such as an NGO, to change or forego water use temporarily or permanently for all or part of an irrigation season. For example, a partial season fallowing agreement calls for ceasing irrigation for some part of the irrigation season. Depending on the crop being irrigated, these agreements can provide significant benefit for both irrigators (in the form of compensation) and for streams (in the form of targeted environmental flow restoration) while having only low to medium impacts to overall farm productivity. Another example is a partial season source switch agreement. Under such an agreement the water user would forbear their use of streamflow but not fallow their land. Instead they would switch to an alternate source such as groundwater, storage rights or another stream source. A final example is a permanent reduction of water use due to conservation or land use retirement, or an agreement not to exercise a "dormant" water right in the future – namely an unexercised riparian water right (which are not forfeited due to non-use). Though examples are illustrative, forbearance agreements can take many different forms and the only limitation is creativity.

2.3.1 ADVANTAGES AND DISADVANTAGES

The primary advantage of forbearance agreements is that they provide an adaptive and flexible tool. They can be molded to fit a number of different of situations based on when flows are needed for the environment, and what triggers the need for flows. Specifically, these agreements can be set to begin on a date certain to respond to typical hydrological conditions, or they can be made flexible, including triggering provisions based on actual, real-time river flow levels and needs. The key is that, because they are private agreements, there are no limits other than what the parties can negotiate, on how these agreements work. In contrast, the statutory language of section 1707 does not specifically allow for partial season environmental flow transfers, but such transfers can be accomplished using a forbearance agreement. Similarly, while California's water code limits "temporary transfers" to one year, forbearance agreements can be made for any number of years, or they can be permanent. One limitation to keep in mind however, is that forbearance agreements can put water rights at risk of forfeiture if they last for too long. Partial season fallowing agreement may reduce the concern regarding forfeiture though consistent nonuse even during only a portion of the season may still risk partial forfeiture. Another advantage to partial season agreements is that they have less overall effect on agricultural productivity because they allow continued irrigation during all or at least part of the irrigation season (depending on whether they involve fallowing or a source switch).

In exchange for this flexibility, the primary disadvantage is that flows resulting from forbearance agreements are not legally protected against diversion downstream of the agreeing party's point of diversion (POD) unless downstream parties are also engaged in an agreement not to divert the water left instream. This limits the usefulness of these agreements to situations where there are few or no downstream diversions, or situations where similar agreements, or flow bypass agreements, can be reached with downstream diverters.

2.3.2 ENVIRONMENTAL FLOW BENEFIT

In the right setting, one where the lack of downstream legal protection of flows is not a concern, forbearance agreements can be very effective at generating environmental flow benefits. For example, partial season forbearance agreements are often made such that flows directly correspond with the time of year when environmental flows are needed most. This means that all of the flow resulting from these agreements provides a meaningful benefit. This contrasts with full season transactions with irrigators that provide environmental flows for the length of the irrigation season regardless of whether flows are needed for the whole season. In headwaters catchments, for example, spring and early summer snowmelt may well exceed permitted diversions so that during these periods additional environmental flows may not be necessary. While it rarely hurts to have more environmental flow than needed, the marginal benefit of flows during the spring can be less than those same flows in the middle or late summer. In sum, the flexibility of forbearance agreements can sometimes allow for more direct and specific targeting of environmental flow benefits than some other transaction types.

2.3.3 WATER COSTS

The amount that will be paid for a forbearance agreement involving fallowing will be subject to the same logic as for temporary transactions that proceed under Section 1707. However, whether the per unit cost is higher or lower will depend on the overlay of a number of conditions that change depending on whether the agreement is a full or a partial season transaction or involves more complicated timing mechanisms (such as fallowing tied to flows rather than a date certain). The first factor is climate; how the timing of a partial season transaction lines up with the hydrograph or water supply. Typically, the expectation is that if there is a particular time of year when streamflow is needed, it is going to be when flow is already in short supply. The second factor is demand by crops and by other water users. Taken together these two conditions usually refer to the summer months when evapotranspiration from crops and pasture is high and rainfall is low (except in areas subject to summer monsoons). In this regard the timing and extent of the crop or pasture response to a period without irrigation, or with reduced irrigation, is of great importance. For example, if it is possible to reduce by 40% the amount of water applied and yet only reduce crop or pasture yield by 20% then that may make partial season transactions particularly attractive to irrigators.

For agreements based on a source switch there may be infrastructure, energy and operations and maintenance costs associated with developing the capacity to move or pump water from the alternative source to the field formerly irrigated by the forgone water right. These may be large or small, depending on circumstances. Where infrastructure improvements are needed there may be benefits to multi-year agreements so that the investment can be "depreciated" across a number of years of environmental flows.

The final overlay is the specific needs of fish and wildlife. Bird and fish migration and lifecycle states may define periods of time where flow is in particular need. For example, a late season migration might mean that partial season transactions are needed after the peak of the irrigation season rather than in the peak summer irrigation months.

These conditions then determine whether it will be necessary to pay more or less for each unit of water than is paid for a different transaction type or duration. Typically, it would be expected that the cost will be higher per unit if the environmental benefit occurs when supply is low and irrigation/municipal demand is high, i.e., in the late summer months. Note however that where there is a well-defined "critical" period for environmental flows, a partial season transaction may still be more cost-effective even if the water cost per unit is higher for the partial season transaction. If the total cost, or amount paid to the water user, is less and the environmental benefits are comparable to those of a full season deal, the partial season deal may be more costly per unit but a more cost-effective transaction. As discussed later, calculating this will require a clear accounting, not just of costs, but also of the environmental benefits of a transaction.

2.3.4 TRANSACTION COSTS

Due to the lack of required formal water right changes, forbearance agreements, especially in California, are likely to have lower transaction costs than other temporary transfers. The primary source of transaction costs for these projects is landowner negotiation, contracting, and monitoring and enforcement. Monitoring and enforcement costs incurred by implementing entities can be higher for fallowing agreements than for source switches and state-regulated transfers, however, this is not always the case and oftentimes, the monitoring can be as simple as ensuring fallowing compliance (for example, driving by the place of use to ensure it is not being irrigated). The more complicated the agreement, the more complicated the monitoring and enforcement requirements might be. For example, fallowing agreements triggered by a specific flow level require a proximate, instream, real-time flow level gauge, which, if not already in place, can be source of potentially high transaction costs.

2.3.5 SOCIAL/COMMUNITY DYNAMICS

As with temporary transfers, temporary forbearance agreements are not likely to cause social or community opposition. Due to the lack of regulatory protection of flows, and the potential to create forbearance agreements that allow for some continued use of water out-of-stream, forbearance agreements can have an even higher degree of general acceptance than formal temporary water right changes. For example, a late season transaction that reduces cuttings of hay from three a year to two may incur minimal notice in the community compared to fallowing ground for a whole season.

2.4 LONG TERM AND PERMANENT ENVIRONMENTAL FLOW TRANSFERS

In California, any transfer longer than one year is classified as "long-term." Section 1707 and the connected transfer laws in Section 1735 do not differentiate between temporary transfers longer than one year and permanent transfers and these two sections are often used for specified periods longer than one year. Section 1707 combined with Section 1701 is the mechanism most commonly used for permanent transfer as these code sections do not require specification of an end date for the transfer. California's approach differs from general EWT practice in the western US (Alford, pers. comm. 2016). Generally, long-term EWTs are those that are more than five years. However, because California limits temporary transfers to one year, what would be called short-term transfers in many other western states (transfers of two to five years), are categorized as long-term transfers in California.

Under Section 1735-1737 of the California Water Code, long-term and permanent transfers are subject to a different set of requirements and processes than temporary transfers. Unlike temporary transfers, long-term transfers are subject to CEQA review and injury review with a public hearing process. There are a number of categorical exemptions from CEQA that might apply, however, none of them is specific to instream flow and, therefore, the role of CEQA is less than clear (Szeptycki et al. 2015). The specifics of the injury review are different as well. Instead of being limited by the "no injury" rule and consumptive use quantification, these transfers can be approved as long as they do not result in "substantial injury to any legal user of water" (Cal. Water Code §1736). While on its face, this looks like a lower bar, it is not clear that the SWRCB interprets it as such.

2.4.1 ADVANTAGES AND DISADVANTAGES

As with temporary transfers, California's laws for long-term and permanent transfers appear reasonable on paper. However, unclear hearing requirements, some lack of clarity on categorical exemptions under CEQA, and landowner fear of being exposed to regulatory scrutiny have made long-term and permanent transfers just as rare, and just as difficult for practitioners to pursue, as temporary transfers in California. Despite the seemingly lower burden on applicants based on the no substantial injury requirement, long-term and permanent transfers take an average of 480 days (571 days for transfers filed by private entities and conservation groups) to process, and only fifteen transfers have been completed as of April 2014 (Szeptycki et al. 2015).

Another disadvantage in California's water code is that any transfer for longer than one year is subject to the same requirements as long-term and permanent changes. While some states, like Oregon, apply different standards of review to long-term (five years or more) and short-term transfers, grouping any transfer longer than one year into the same process as permanent transfers could severely hamper short-term transaction activity in the range of two to five years. These types of short-term transactions may be important in helping to build toward longer term and permanent transactions and hampering activity in this time range could therefore unduly hamper environmental flow restoration programs.

This brief review of the 1707 rules suggests a fundamental difference between California and other states with active EWT programs. When it comes to reviewing water right transfers, very short-term transfers appear to be exposed to a high bar in terms of quantification and injury prevention, while on the other hand, reasonably short-term (two to five year) and long-term/permanent transactions are subjected to a lesser burden on approval but a higher burden in terms of process. The logical path is to subject long-term and permanent transfers to high levels of both process and scrutiny and to subject short-term transactions to lower levels because the stakes are higher for changes with a longer time horizon. However, these distinctions are less than clear in practice. When combined with CEQA and other administrative issues, process issues and questions have likely contributed to limited environmental transaction activity since the adoption of Section 1707 in 1991.

2.4.2 ENVIRONMENTAL FLOW BENEFIT

For the limited number of environmental transactions longer than one year that have passed through the gauntlet of California's long-term/permanent transfer process, the result is likely significant environmental flow benefits. First, long-term and permanent transfers provide added certainty that flow benefits will be in place over a longer, and in some cases permanent, time period. These benefits will also be legally protected from diversion according to their priority meaning that durable, senior environmental flow water rights are in place. Additionally, because long-term and permanent transfers are subject to a "no substantial injury" standard, at least according to the wording of the water code, there are conceivably situations where the amount of water protected for the environment will exceed historic consumptive use of the water rights being changed.

2.4.3 WATER COSTS

Of course, in return for the substantial environmental benefit, there will be a significant payment made to the irrigator who is reducing their water consumption over a long period of time or permanently. As for the annual leases, this cost will vary throughout the state in accordance with the opportunity costs faced by irrigators. An issue in California is however the degree to which most of the state, i.e., the Sacramento-San Joaquin Valley, is well-plumbed with infrastructure so that the prices paid for water by high value farmers in the Central Valley and the growing metropolitan areas in Northern and Southern California will influence prices across most of the state. The exceptions would be the coastal watersheds and the Klamath River Basin in Northern California. However, even in these regions water scarcity, and niche/illegal crops (like wine grapes and marijuana in coastal watersheds) may keep prices higher than observed to the north in the Columbia Basin.

In other words, long-term and permanent transaction will provide significant and long-term benefits but the costs will be significant. There is no a priori judgment that can be made about whether annual, long-term or permanent transactions are more cost-effective. Nor is there any empirical study demonstrating that one type of transaction always has lower or higher water costs than the other.

2.4.4 TRANSACTION COSTS

Due to the uncertainty caused by the potential for public hearings and protests, and the potential level of effort necessary to show no substantial injury of long-term and permanent transfers, transaction costs for these EWT tools are relatively unknown but should be assumed to be high. However, due to a relative lack of experience with implementing these tools for environmental purposes (only fifteen completed as of April 2014), it is not clear how high transaction costs for this tool are in California. Based on experience elsewhere, it can be expected that transaction costs are high for these transactions, and higher than for annual or short-term transactions. For example, in Oregon, transaction costs for permanent environmental transfers are quite high due to lengthy landowner negotiation and project development costs and expensive and sometimes lengthy processing timelines. It is another thing altogether in California, where the protest and hearings process and environmental review process under CEQA are more unknown quantities due to the relative lack of experience. Planning for high transaction costs is possible, but ideally there would be some known ceiling. Planning for high transaction costs without such a ceiling, as is required by current California law, is yet another element that likely hampers environmental flow protection in California.

So, total transaction costs are likely higher for long-term or permanent transactions. Such transactions reflect higher risk for the buyer, the seller and the administrator. Therefore, more due diligence is required and a larger premium may be required to convince a water user that they should give up their water use for such a long time, or in perpetuity. Nonetheless, the benefit gained is a long-term or permanent benefit and, thus, the transaction cost is allocable to a larger amount of environmental benefit. Thus, it does not follow that the transaction costs of long-term or permanent transactions are higher in per unit of environmental benefit terms than for annual or short-term transactions. Unfortunately, there are no empirical studies of this nature. Transaction cost studies have not distinguished between short-term and long-term transactions (Garrick and Aylward 2012).

2.4.5 SOCIAL AND COMMUNITY DYNAMICS

In addition to unknown and unknowable, but potentially significant transaction costs and other disadvantages of long-term and permanent transfers in California, the social and community dynamics of long-term and permanent transfers are more difficult than many other EWT tools. One of the primary fears of agricultural communities is that water transfers, especially for the environment, will result in widespread removal of water from currently productive agricultural land. Long-term (ten or more years) and especially permanent environmental transfers stoke this fear more than any other mechanism. Conversely, communities and community members that depend on healthy rivers fear that, absent permanent reduction in agricultural water demand, salmon and orcas will go extinct, tribal members will continue to go without fish, ancient tribal cultural traditions will be lost, commercial fishing and recreation economies will suffer, and future generations will lose their natural heritage.

While these dueling social and community dynamics can cause local tension and conflict within/across communities, the effort to deploy environmental water transactions runs largely into the fears of the agricultural communities. To a limited extent, these fears can be ameliorated by focusing the use of these tools on marginally productive land and lands that are not owned by families who are dependent on irrigation for their livelihood. This often manifests itself in limiting the application of long-term and permanent transfers to so-called hobby farms and specific tracts of less productive land owned by career and lifetime farmers and farming families.

An alternative to ceasing agricultural production is to develop projects that involve change in timing of diversion and switch from riparian claim to an appropriative storage right in exchange for a 1707 dedication of the water previously diverted during the critical time period (typically late summer but could coincide with some environmental condition that occurs at another time of the year). Although, this approach is not discussed in detail in this report, it is a fairly common approach for coastal salmonid streams and can be a win-win for the environment and the water user (Alford pers. comm. 2016). To the extent that the appropriative storage right provided water to another consumptive use, this approach simply displaces the impact on production to another location.

Another issue that can arise, depending on local taxation policies, is whether long-term or permanent water transfers change the tax status of agricultural land. Removing preferred tax status from land could be a sticking point for negotiations. From a community perspective, depending on specific policies in place, removing water from land might result in reducing the taxable land base of a county and generate opposition on that basis. On the other hand, voluntary restrictions on water or land use through land/water conservation easements may result in significant tax incentives for individual landowners.

Social and community opposition from the agricultural community to long-term and permanent transfers is by no means a reason not to pursue these projects, however it is important to keep in mind if long-term viability of an environmental flow restoration program is important.

2.5 CONSERVED WATER TRANSFERS

Section 1011 of the California Water Code states that "the term "water conservation" shall mean the use of less water to accomplish the same purpose or purposes of use allowed under the existing appropriative right." It is important to note that both fallowing and crop rotation are included in the definition of conservation efforts. However, there is a caveat; that these activities be carried out "in the course of normal and customary agricultural production to maintain or promote the productivity of agricultural land."

Section 1011 allows for the transfer of this "conserved water" in the same manner as any other water right subject to transfer. More specifically, section 1011 exempts water that is not used due to "water conservation efforts" from California's forfeiture laws. However, simply claiming conserved water this way does not result in regulation of the saved water instream. Section 1011 does go on to add that "Water, or the right to the use of water, the use of which has ceased or been reduced as the result of water conservation efforts . . . may be sold, leased, exchanged, or otherwise transferred pursuant to any provision of law relating to the transfer of water or water rights. . . " (Cal. Water Code §1011). Therefore, water that results from conservation efforts that result in the use of less water to accomplish the same purpose or purposes of use allowed under the existing water right, can be transferred for one year or less to environmental use under sections 1707 and 1725, or can be transferred for longer than one year or permanently under sections 1707 and 1735. Section 1011 does require water users undertaking conservation efforts to report every three years and to prove that the conservation effects are ongoing.

Fallowing for the purposes of EWTs has already been covered above under water leasing. When it comes to water conservation, this is likely to mean an increase in water use efficiency. In other words meeting the intent of the language in the statute of the original beneficial use but with the pumping or diversion of less water. Efficiency may be increased through a number of different pathways: increasing the ability to limit water diversion to only what is needed at a specific time, reducing tail water that remains unused at the end of a long irrigation ditch, decreasing leakage and other sources of inefficiency in transmitting water from a diversion to a place of use, increasing the efficiency of application of irrigation water on-farm, and other similar projects can all result in water available for transfer to environmental uses (Aylward 2008; Aylward 2013d). It is important to note that, as described above, California does not provide a different pathway for transferring this type of water. Therefore, the following sections will not repeat discussion of the Section 1707, 1725, and 1735 transfer pathways from above. Instead we focus on aspects of conserved water transactions that will differ from the prior discussion due to these transactions arising from an increase in efficiency rather than a reduction in consumptive use.

2.5.1 ADVANTAGES AND DISADVANTAGES

A number of western states do not explicitly recognize a legal right to transfer and legally protect conserved water. California's recognition of this ability is a critical advantage of the state's water law. The ability to conserve water and legally protect the resulting flows past downstream diversions can be a powerful EWT tool. Additionally, water conservation projects can often be a "low-hanging fruit," especially in small farming communities without access to large water management infrastructure. These communities tend to have significant potential to increase water use efficiency and unlock a correspondingly significant amount of water for environmental flows. The primary disadvantages of this tool are the limitations of California's water transfer processes as discussed above, as well as potentially high transaction costs and limited environmental flow benefits discussed further below.

2.5.2 ENVIRONMENTAL FLOW BENEFIT

Inefficient water use often results in large amounts of water being diverted from streams. The portion of water not consumed through crop production may then return to the source from which it was diverted at some distance down gradient, i.e., downstream. This return may occur directly as overland flow back to streams or through the recharge of the aquifer and eventual groundwater discharge to streams. The sources of these inefficiencies are leaky canals, laterals, ditches, as well as seepage from on-farm application of water and tail water at the end of fields and ditches. Addressing these inefficiencies can therefore help address river reaches between the original point of diversion and a downstream point of return flow, but these benefits are not protected past downstream diverters. It is critical to keep in mind that this is different that the impact of reducing consumptive use. Reducing consumptive use can add flows that were formerly lost to the system entirely and therefore those benefits will last much further downstream than for water use efficiency projects.

All of this is not to say that conserved water transfers do not have environmental benefit. First, long irrigation conveyances are common and the result is that the point of return flows for water that leaks from these conveyances or off of the place of use can be miles downstream from the POD. In this case, increasing flows in the reach between the POD and point of return flows can have significant benefit, especially if the intervening reach was particularly problematic for aquatic species and habitat. Second, some water that is lost to inefficiency may not return to the stream. In some cases, unused tail water is returned to a different source than it was diverted from. In other cases, water that leaks out of a conveyance or off of a farmer's field seeps into deep aquifers or another area that is hydrologically disconnected from the surface water source from which the water was diverted. In these cases, the impact of transferring the conserved water is identical to a consumptive use transfer—the water was being consumed, just not via evapotranspiration of vegetation.

Another important potential impact to keep in mind with water use efficiency projects is that in many cases, they can have negative environmental consequences. For example, where the seepage from a leaking irrigation ditch has provided water for an adjacent stream or shallow groundwater aquifer, reducing the seepage can reduce instream flows. Similarly, inefficient water use early in the irrigation season can sometimes be the source of late summer base flows in parts of a watershed due to the lag in time between the water leaking and percolating back to the original source.

Conserved water projects can have significant environmental benefits if the conserved water is dedicated for environmental use. Unfortunately, many publicly funded water conservation projects do not require that conserved water be dedicated instream. It is also critical to understand the difference between increasing water use efficiency and reducing consumptive as a basis for EWTs and to evaluate projects accordingly.

2.5.3 WATER COSTS

Conserved water projects vary from "hard" infrastructure solutions like piping ditches, to "soft" approaches such as changing irrigator behavior and water management practices. Hard solutions often require the irrigation entity to invest in capital infrastructure. Ideally, the conservation funder will provide all or a portion of the funds to instigate the water conservation measure in return for putting a proportionate share of the saved water to an environmental use. While some conservation projects can be relatively simple, such as changing diversion timing and patterns, other projects can be very expensive. There is also a trade-off in the timing of the costs of generating conserved water. Hard solutions require up-front funding, whereas soft solutions may require larger continued expenditure on staff time (to implement savings). It is also the case that investing in capital items, like piping or lining a ditch, may also reduce ongoing operations and maintenance costs. Thus, there may be cost savings as well as costs to these improvements. Consideration of the net costs of conserved water is another complicating factor to examining water costs for these transactions.

2.5.4 TRANSACTION COSTS

Conserved water projects may also involve a much larger investment of effort by the irrigation partner, particularly when they involve planning, design, engineering and construction related to irrigation district conveyance systems. In this way these transactions are different than the others, where the bulk of the effort is made directly by staff of the conservation group. Some of these costs may need to be financed by conservation funds. Alternatively, the irrigation partner may have other sources of funds for these, including assessments paid by members of a ditch company or irrigation district. With infrastructure solutions, the major transaction costs will be the various engineering and design studies, as well as permitting costs.

2.5.5 SOCIAL/COMMUNITY DYNAMICS

Water conservation projects generally face relatively low social and community barriers. These are particularly low if they involve taxpayer-funded water diversion infrastructure improvements for irrigators with no requirement that conserved water benefit the ecosystem. Growing public knowledge about water scarcity has led to fairly widespread acceptance of the need to increase water use efficiency. So on their surface, many agricultural communities are at least initially supportive of these projects. However, there are a number of potential sources of opposition from agricultural communities. First, conservation alone is more acceptable than conservation paired with a long-term or permanent environmental transfer. Transferring conserved water to environmental uses can be met with the same opposition as long term and permanent transfers of other water rights. People and communities may question why conserved water is not being used to shore up existing junior out-of-stream rights or expand irrigated acreage or other out-of-stream uses.

Another source of opposition from irrigators can come in the form of historic preservation or amenity arguments. What some see as an inefficient headgate structure or a leaky irrigation canal, others see as historic features or a water feature flowing through their backyard and around which they developed their landscaping or community green spaces. When the structure is to be decommissioned and removed, or the “stream” is proposed for piping, significant opposition often results from developers and homeowners who feel entitled to the maintenance of the status quo. In sum, while water conservation can often yield some low hanging fruit in an EWT program effort, it is not without pitfalls and can require careful navigation of social and community issues.

2.6 ACQUISITION OF LAND AND WATER AND TRANSFER/FORBEARANCE OF APPURTENANT WATER RIGHTS

The final EWT tool discussed in this report involves the fee title purchase of land with appurtenant water rights or the establishment of conservation easements on land. These actions are only considered EWTs if there is a subsequent dedication of these water rights to environmental uses. This dedication may be explicit through use of the 1707 process (as discussed earlier) or by simple forbearance. For example in the arid southwest the purchase of lands and cessation of groundwater pumping may be a path to flow restoration. Land purchases can be a powerful tool as they avoid the complex problem of leaving a landowner with the land but no water. They also are conceptually simpler as they avoid the high cost of negotiating water transactions with landowners and the compromises that are often necessary. In particular, where opposition or impediments to trading in water rights exist, and/or are leading to speculative pricing of the water, these purchases also provide a path forward for the conservation group. This approach avoids the knotty problem of how much water is worth separate from land. Instead the full bundle of rights is acquired.

Conservation easements are another variation on this theme, with a conservation entity effectively acquiring (and retiring) only the development rights for a property. The difficulty with conservation easements is that they typically retrench the agricultural use of the property, making subsequent removal of the water rights unlikely. Conservation easements must therefore be planned with an explicit eye towards the dedication of all or a portion of the water rights to environmental use, otherwise these agreements will tend to "freeze" irrigation water use in place. This removes the water rights from the EWT playing field, simply putting more environmental demands on the other, remaining irrigation water rights. Given the difficulty of using conservation easements for the purposes of an EWT, the discussion below focuses on the fee title acquisition of land and related interests.

As with conserved water, the transfer processes are not unique and discussion of their relative advantages and disadvantages is not repeated here. Instead we focus on the differences that arise when the property is itself the subject of the transactions.

2.6.1 ADVANTAGES AND DISADVANTAGES

Land purchases have the distinct advantage of giving full control over all aspects of the process to the new landowner, removing the need to negotiate every term of the water transfer and surrounding actions. They also have the advantage of allowing for holistic river restoration that includes environmental flow restoration, but also includes riparian re-vegetation where needed, and other streamside and upland restoration actions.

The primary disadvantages are the expense involved and potential social and community opposition (both discussed below) and also the problem of scale. It is not uncommon for irrigated land to be sold connected to large tracts of un-irrigated land and large federal/state land leases. In many communities, the sale of purely irrigated acreage is more limited than whole-farm sales. The result is that buyers are forced to pay for vastly more land than is required to strictly get the desired environmental flow benefits. This is not an issue for conservation groups that have both a land and water focus, but can make land acquisitions a difficult proposition for specialized groups that focus only on water. However, where scale and other factors line up, acquisition of irrigated land and subsequent transfer of water rights to environmental uses can be effective.

2.6.2 ENVIRONMENTAL FLOW BENEFIT

For the most part, the discussion of environmental flow benefits from land and water acquisitions mirrors the discussion above for long-term and permanent transfers. Where land and water acquisitions gain an edge is in the ability to combine water transfers with upland and other actions that can contribute increases in flow. For example, a parcel of land with irrigated lowlands that also includes degraded upland habitat can provide two different flow benefits. First, the transfer of water rights to environmental use via reduction of consumptive use results in direct flow benefits. Additionally, restoring the health of the upland habitat can increase natural water storage and slow storm and spring runoff, thereby helping to boost base flows attributable to upland hydrologic functions. Land and water purchases provide the unique opportunity of implementing a suite of compounding, holistic flow and habitat benefits that few EWTs can provide on their own.

The other distinction worth mentioning is that traditional EWT tools such as lease and transfer of water rights put water to environmental flows when they "close." Purchasing a property that includes a homestead, irrigation and non-irrigated land incurs a number of different obligations and activities for the buyer, of which moving the water to environmental flows is just one. There is the practical difficulty of prioritizing the latter activity. For this reason, most water trusts or non-profit entities that have explicit missions in the EWT arena tend to eschew these types of transactions.

2.6.3 WATER COSTS

One of the advantages of traditional EWTs such as leases and transfers is that the water cost is clear at the outset. This clarity dissolves when pursuing a whole farm or ranch purchase. This, as the cost of the water will be the cost to purchase the property net of any revenue from disposing of the non-water related property and interests. Will the property be marketable without the water rights, or will it be necessary to retain a portion of the rights to resell the property? Or if there is to be a period of transition during which the land and water rights, the associated improvements and the land use are reconfigured, before disposing of the property and putting all or a portion of the water to environmental flows, what is this carrying cost of this activity? And what will the disposal of the reconfigured property bring in in the form of revenue? It could well be that the net water cost of the environmental flow that results from this effort will be less than those that would have been incurred in paying the landowner only for the water rights. But it could be that cost will be higher.

Of course, if it is literally impossible to buy water rights separate from land then buying the ranch or the farm (with water rights) may be the only tractable approach. In this circumstance, in order to avoid the transaction costs associated with buying land and water, it may be effective for the conservation group to offer the landowner up to the value of the whole property to obtain the water rights. But this will depend on the prospects for retaining and re-marketing the land and remaining interests in the property once the water is removed. It may be that the water associated with a property is of declining marginal value, meaning that it is possible to buy the farm, remove most (but not all) of the water and remarket the property, and end up paying less for the water on balance than through a permanent water deal.

2.6.4 TRANSACTION COSTS

Transaction costs for environmental transfers are discussed above and are not repeated here. However, land acquisition requires additional, and substantial due diligence and transaction expenses beyond those of environmental water transfers, especially if federal and or state funds are used in the transaction. First and foremost, land transactions have potentially complicated appraisal requirements that vary depending on the nature of the entity purchasing the land as well as the source of funds for the purchase. Required due diligence is also more broad, costly, and time consuming, especially as it is additive to, and not in place of required due diligence on the water rights and water use. The one bright spot may be that negotiating and implementing land purchases may be simpler than similar activities required for pure water transactions, given the complexity and unfamiliarity of the latter. Broadly speaking, the transaction costs for land/water purchases can be higher than almost all other EWT tools for a similar amount of water acquired. However, weighed against the potentially greater overall environmental benefit, and the level of control that land ownership provides over the entire water transfer process, these transaction costs may be justified.

2.6.5 SOCIAL/COMMUNITY DYNAMICS

Purchasing land for conservation can, in many instances, be more acceptable than pure water deals. This is partly due to the fact that land conservation has been ongoing far longer than water transactions and so many communities have been exposed to it in the past. Common issues present with land/water purchases that are not present for pure water deals include concerns about removing productive land from the local tax base if the entire purchase is enrolled into conservation easements. Some of these issues can be avoided if the purchasing entity is planning to manage the land as "working land" and keep some level of agricultural production ongoing. As with other EWT tools, land/water purchases can generate social and/or community opposition, however such opposition should not prevent land/water purchases and can be minimized.

2.7 SUMMARY

This section discussed five different environmental water transaction tools that can be used in California to increase environmental flows to benefit aquatic habitat and species that rely on this habitat. For each EWT tool, this section described the basic mechanics, including basic legal and practical considerations, as well as key advantages and disadvantages. In addition to describing the tools and their relative pros and cons, this section discussed potential environmental flow benefits, water costs, transaction costs, and social/community dynamics for each tool. Figure 1 below shows a very approximate attempt to compare the six tools based on the discussion above. Each tool is placed on a spectrum from good/best to bad/worst for these four assessment areas.

Figure 1: Comparative Analysis of EWT Tools

Environmental Flow Benefits	Water Cost	Transaction Costs	Social / Community Dynamics
Lowest Flow Benefits	Lowest Cost	Lowest Cost	Lowest Risk of Opposition
Temporary Transfers	Short-term Partial Season Temporary Transfers	Short-term Partial Season Temporary Transfers	Short-term Partial Season
Conserved Water Long-term Transfers Short-term Partial Season Fallowing	Long-term Transfers Permanent Transfers Land/Water Purchase	Conserved Water Long-term Transfers Permanent Transfers	Temporary Transfers Conserved Water Land / Water Purchase
Land/Water Purchase Permanent Transfers	Conserved Water	Land/Water Purchase	Long-term Transfers Permanent Transfers
Highest Flow Benefits	Highest Cost	Highest Cost	Highest Risk of Opposition

Looking at the tools in comparison to one another highlights several important summary patterns. With some variation, those tools with the highest potential flow benefits also come with potentially higher water and transaction costs, as well as potential for social/community opposition. The converse is also true. Often the tools with the lowest potential environmental benefits (in this case, primarily due to their lack of durability) also have the lowest prospective costs and risk of opposition. Another useful way to think about this general finding is to consider it from a programmatic perspective. The process of building an EWT program often involves early phase projects that have low costs and low risk of opposition under the theory that these projects help build trust in a community and help to build toward more high risk, high cost projects at more mature phases of programmatic development. As a consequence, early stage projects are likely to have lesser and short-term environmental benefits. The theory being that as time passes and the programs mature there will be a shift in transactions to those that have more significant and secure environmental benefits.

No one EWT tool is a silver bullet. Each of the tools reviewed above have distinct advantages in certain scenarios and drawbacks in others. California's complex and sometimes confusing legal framework for environmental transfers does not help to crystalize any clear "winner" among the analyzed EWT tools either. However, it is critical to understand some of the tradeoffs and intricacies represented by the figure above and the foregoing analysis before delving into developing a metric for cost-effectiveness of EWTs.

In the next section we provide a listing and discussion of the potential metrics that practitioners and others involved in EWTs might deploy to assess the cost of EWTs. The following section does the same for the effectiveness of EWTs. We then discuss the ways in which these may be usefully combined into measures of cost-effectiveness.

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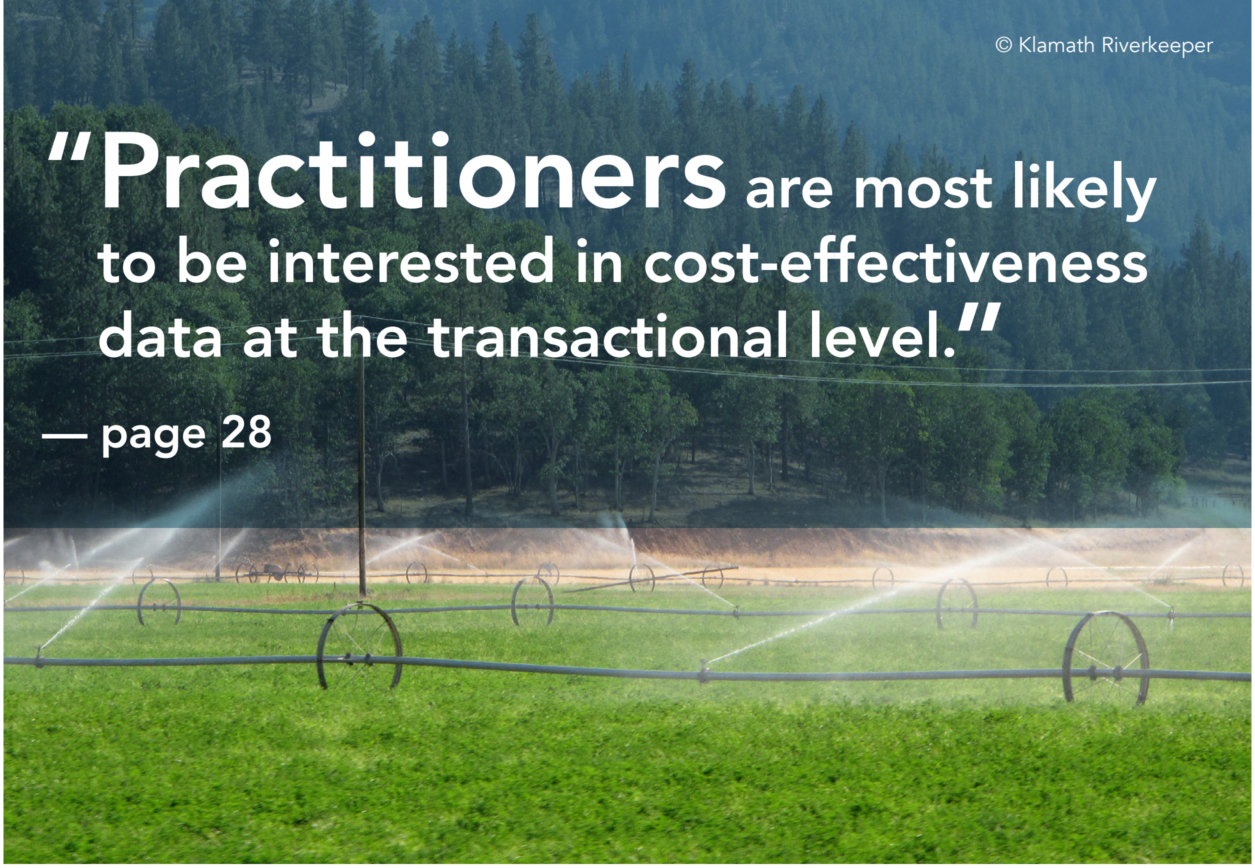

3. COST-EFFECTIVENESS: PERSPECTIVES AND PURPOSE

There are a large number of different participants and stakeholders involved in environmental water transactions. The joint use of cost and effectiveness data as a measure or indicator of cost-effectiveness has a number of different applications and purposes that vary from one group to the next. To ensure that we capture the full range of potential perspectives, we walk through each potential user group or audience in order to identify the type of cost-effectiveness information that is likely of most relevance to the group. For this purpose we aggregate these perspectives into the following:

1. **Practitioners –** staff carrying out transactions.
2. **Practitioner leadership –** executive directors and non-profit boards that approve transactions or transactions programs.
3. **Funders –** state agencies, federal agencies, foundations, corporate entities and individuals providing funds for transactions.
4. **Advocacy groups –** environmental or agricultural interest groups that are stakeholders in the water arena and are interested in accountability and outcomes of transactions.

We leave out regulators as in state and federal entities that administer changes in water rights or water contracts, as these activities are not often related to cost or effectiveness indicators but are more related to efficacy, i.e., rather whether established rules for such changes have been followed and that the change is permitted under statute and rule.

3.1 EWT PRACTITIONERS

Practitioners are the organizational staff that carries out environmental water transactions. They may work for non-profit conservation groups, environmental foundations, state agencies or as consultants to conservation buyers. As practitioners, they are the ones that will plan, develop, manage, monitor and evaluate EWTs. As such they are the likely implementers of cost and effectiveness data and metrics. Practitioners also have the most direct stake in what the other groups think about the cost-effectiveness of their transactions, as practitioners must:

- decide which transactions to put forward for negotiation with landowners, approval by superiors and funding;
- convince funders that their transactions and staff time are worth of funding;
- convinces sellers to engage in transactions; and
- demonstrate to stakeholders that their transactions are effective use of societal resources.

As such, practitioners are the nexus for cost-effectiveness measures and will have an interest in providing a full range of cost-effectiveness metrics to these various audiences. Practitioners also should have a fairly unique and holistic perspective with respect to the cost-effectiveness of their transactions. Nobody will know the streams, the landowners and the interplay of various factors that determine the success or failure of a proposed transaction as intimately as the practitioner.

With regard to transaction costs, practitioner alone will understand the true complexity of the challenges and hurdles that they face, often on a daily basis. They alone will understand how the pace of their work is not of their own choice, but rather a composite of how fast and hard they are willing to push and how ready, willing and able the water user community is to engage in transactions. It is therefore safe to say that when it comes to transaction costs, whatever formal metrics can be defined and measured, the practitioner is the person most affected and most concerned by these costs. Practitioner effort to work through the various phases of developing, funding and implementing a contract with the water right holder or landowner, and to develop and shepherd the application through the appropriate channels and obtain the necessary approvals for environmental flows typically form the largest component of transaction costs.

By implication here, outside efforts to measure transaction costs, will often be seen as very simplistic representations of a complex reality. This is not to say that such efforts are without merit, but rather to say that practitioners are likely to be uneasy with such efforts, both because of the practical difficulty of measuring these in an accurate fashion and the potential for such measure to reflect on individual or organizational performance.

With regard to water costs, the practitioner will have this information and there should be little debate about the accuracy of the figures. What is paid is paid. Whether or not the seller complies with the contract or whether the flows are realized as expected are another matter, and one related to effectiveness. But the costs are clear. What may not be clear to the practitioner is how to evaluate those costs over time. And the trend in costs (or price of water) over time is of great importance to the practitioner who must budget for and obtain funding for transactions. The practitioner, thus, should have a great interest in understanding cost trends over time, and whether they are rising or falling. But rising costs over time are in some sense normal. Therefore, the practitioner should really be interested in whether costs are growing slower or faster than inflation. However, as shown in the survey later in this report, practitioners do not normally work with inflation-adjusted costs, and therefore are not aware if costs are coming down or going up with respect to the general level of price inflation for other goods and services in the economy.

With regard to performance metrics, the practitioner would be interested in any and all metrics, but the term practitioner implies someone who is "practical." This means that the practitioner has many jobs and roles to undertake and will often have limited ability to study the results of their transactions. Ideally, there is a monitoring plan and monitoring staff. But funding for monitoring can be hard to obtain and haphazard, at best, in terms of donor commitment. The practitioner is a staff position aimed at undertaking environmental water transactions. As such, their primary indicator of success is transactions completed and flow obtained for environmental use. Advanced effectiveness monitoring and evaluation is unlikely to be their core strength and may not even be carried out by their organization (as discussed early). In any event, much of this work happens after the transaction is selected, approved, funded and closed.

3.2 EWT PRACTITIONER LEADERSHIP

The role of directors and boards is to exercise leadership, supervision and fiduciary responsibility. Also, in most cases there is a community relations role that such leadership may or may not provide, depending on their makeup. For place-based transaction organizations with local boards or advisory councils such relations may be an important focus. This may mean less of a reliance on technical metrics of success, such as cost-effectiveness and more reliance on other social and economic criteria, such as community acceptance, absence of controversy and local funding. Nevertheless, there is the presumption that leadership's role is to ensure that staff stay on track to meet strategies and plans by achieving desired outcomes and staying within budget. As such leadership should very much require well-organized and documented reporting from staff, including on cost-effectiveness of transactions. Leadership may also play a role in pushing the discussion of cost-effectiveness beyond pure cost per unit water discussions into discussion of how to improve efficiency of transactional processes (i.e., lower transaction costs) and how are the individual transactions beginning to stack up to meet flow objectives and whether meeting those objectives is resulting in desired habitat and/or population goals.

Leadership, however, has limited time to spend on these and other topics. It is therefore likely that leadership will be looking for aggregated, time series indicators that best suggest accomplishments by geographic area and type of transaction. Most likely, changes in strategy in response to these metrics, for example switching efforts from a high cost transaction type to a low cost transaction type, will be a matter for leadership to decide. In some cases leadership may even play an active role in setting the amounts that staff are allowed to pay for different types of projects. Obviously, this is facilitated by thorough cost-effectiveness tracking and reporting.

3.3 EWT FUNDERS

Funders will vary considerably in their understanding and sophistication with regard to EWTs. Large, geographically diverse and long-term programs of funding such as the Columbia Basin Water Transaction Program managed by National Fish and Wildlife Foundation with funding from the Bonneville Power Administration (BPA) will track costs and effectiveness as part of their overall program management role.

With staff that formerly served as EWT practitioners the CBWTP appreciates the perspective of the practitioner, but also must respond to the needs of the program's technical advisory committee that reviews transactions for funding, the objectives of their source funder BPA, and the appointed representatives from each of the four states on the Northwest Power and Conservation Council. For such programs the ability to use cost-effectiveness information in shaping the program means whether or not this information can be used in funding allocations along with other institutional priorities, such as BPA's fish and wildlife obligations under biological opinions on the Federal Columbia River Power System. For example, high priority reaches for anadromous fish have historically had priority over reaches with resident fish populations. While the Independent Science Review Board (serving the Council) has shown an interest in the cost-effectiveness of the CBWTP program, the day-to-day reality is that these geographical priorities and the shortage of transactions in the key anadromous reaches have meant little need for prioritization based on cost-effectiveness information.

Smaller funders that invest here and there in programmatic development and water transactions themselves may or may not collect and/or use cost and effectiveness data in their decision-making. Typically they will not be involved enough or have staff with the expertise to handle such information in a comprehensive manner.

The relative under-utilization by funders of cost-effectiveness information can be traced to a number of factors. First, as alluded to above is the relative paucity of desirable transactions relative to available funding. This reflects the relative immaturity of many EWT programs as well as the lack of functioning water markets, where for example a conservation buyer may just place bids to buy water for the environment. So there is a lack of need or demand for this information by funders. Second, there may be a lack of supply. There is a relative lack of scholarship and effort in this area. Many EWT programs are led by attorneys and staff with an environmental science background, with economic expertise in short supply.

Finally, the relative newness of the water trust movement and EWTs just means that to date most groups have been "doing their own thing" and so efforts and funding to develop standards and guidelines have largely been absent. Capacity building in the field has consisted of workshops and meetings aimed largely at building practitioner skill sets. Only recently has a training course originally instituted by the CBWTP become a formal graduate level course on EWTs at Oregon State University (as developed by the authors of this report). In the accompanying EWT handbook (funded by the Walton Family Foundation) there is no chapter on costs, just one on water rights appraisal (Aylward 2013b). To date, there is no association of professionals in this field or accreditation of any kind.

The relative lack of demand and supply has meant there is no united funders guide to cost-effectiveness. Still there have been efforts in this direction. Again under the CBWTP, efforts have been made on effectiveness and water costs. In partnership with the Bonneville Environmental Foundation, NFWF and CBWTP have partnered on trying to formalize an EWT flow accounting framework (McCoy and Holmes 2015). In addition, every few years, CBWTP commissions WestWater Research LLC to compile a report on water costs of the program EWTs.

3.4 SELLERS

Sellers to EWT programs, particularly landowners, water right holders and irrigation entities would not normally be expected to be concerned about the costs of such programs, in particular transaction costs. But what might be of interest is the amount of money paid for water. There is an argument to make that in the absence of robust water markets, making information about prices paid to lease and acquire water and water rights public would assist in attracting interested participants to EWT programs. There is also an argument that transparent, "market" data would eliminate certain inefficiencies experienced by practitioners.

It is not uncommon for practitioners in new EWT programs to take considerable time, even years, to successfully locate a willing seller. Research has shown that people holding an asset that is not frequently traded and, therefore, for which there is no market and/or the market value is uncertain will focus on the risk of loss and not the potential gains from the sale when asked to sell the asset. This "endowment effect" implies that it will be difficult to persuade such asset holders to part with property of this nature. Water rights clearly fit this definition of a long held asset that is rarely if ever traded in a market. By implication the practitioner's job is largely one of overcoming this fear of loss – and persuading the water right holder to focus on the potential gains of the transaction. A practical implication is also that the practitioner may need to pay a premium to persuade a water right holder to sign on the dotted line or consider land acquisitions as a means to conduct EWTs without having to overcome the endowment effect. Providing accurate and timely market information is one way of minimizing this endowment effect over time.

3.5 ADVOCACY GROUPS

Advocacy groups that take an interest in EWT programs may be proponents or opponents of environmental flows. More precisely on the environmental side some groups are opposed to the idea that money, particularly public money, be paid to irrigators and irrigation entities to put water to environmental use. Rather the stream and associated public benefits should have first call on the water and statutory or judicial avenues pursued to ensure that water is regulated in this fashion. On the other side are farming and ranching special interests that are concerned by any action that substantiates a claim to environmental water and by the removal of water from these activities. Both of these groups may oppose EWTs based on their costs. Environmental groups may feel that spending tax dollars for this purpose is a waste and farming/ranching interests will feel likewise. The rational of each group is the inverse of course. On the environmental side, environmental uses are seen as the highest value use with irrigation water of low value; whereas farming/ranching interest feel that not letting water "touch ground" before it leaves the watershed is an economic loss to the community.

Anti-EWT groups, whether to the left or the right, will see cost data as confirming that EWTs are a waste of public or other funds. However, there are other advocacy groups towards the middle of the spectrum that may be more interested in simply the wise use of public funds. For such groups comprehensive cost-effectiveness data would be empowering as it would allow them to understand and follow trends over time in cost-effectiveness as well as to compare the benefits of expenditures in different regions and on different transactions. In this case transparent information would foster informed debate about public policy.

3.6 CONCLUSIONS ON PERSPECTIVES

This discussion leads to the suggestion that practitioners are the most interested and affected party when it comes to transaction costs and water costs, and indeed when it comes to the cost-effectiveness of transactions. Presumably, other things equal, practitioners would like their work product to look better than that of others and to show continuous improvement. There are some caveats to each of these statements as explored below, but the second statement rings true and is often expressed by practitioners. The practitioner will be interested in using cost-effectiveness data to compare and contrast different transactions at the reach or program level, i.e. as one element in transaction scoping and design.

So, practitioners are most likely to be interested in cost-effectiveness data at the transactional level as a means to improve their performance year to year.

Not surprisingly, there are a number of limitations to the idea that cost-effectiveness information may be used to compare the transactions of one practitioner (or EWT program) versus another. First, perhaps more than others the practitioner will be well aware that the costs of water in different "reaches" or "markets" will not be comparable one with the other, and that the costs-effectiveness of transactions will vary between and within types of transactions. So, when it comes to the use of cost-effectiveness data by others, such as leaders, funders or advocates, to suggest that funding should go to this or that organization, or to this or that program or reach, practitioners may be agnostic (or disagree).

For example, an EWT practitioner for the (hypothetical) Bear Creek Water Trust may be expected to use cost-effectiveness data to improve the performance of their transaction portfolio in Bear Creek. However, should the board of the trust suggest that the practitioner engage only in a particular type of transaction, for example one-year leases, because these are the most cost-effective type of transaction, the practitioner will likely push back. They may see the full suite of transactions as working together. A program of transfers may only be acceptable to irrigators if accompanied by more expensive investments in conserved water transactions. Or the practitioner may see that the flow target in Bear

Creek cannot be met just with leases, but requires water from other sources, such as split season transactions and conserved water.

The point here is that cost-effectiveness will never be the only reason to do one type of transaction versus another. There are other criteria that the practitioner and all other participants will be wise to heed in planning for success.

Should a funder or advocate cite cost-effectiveness data as the rationale to move all funding over to the Salmon Creek Water Trust in the adjacent watershed it is unlikely that staff at the Bear Creek Water Trust will be in agreement that the data should be used in this way. They will likely feel that the metrics are imperfect representations of the value of their transactions and flow restoration program and they most likely will maintain that other criteria that should factor into the decision. To some extent this is a predictable and not un-reasonable consequence of differing levels of perspective of these participants. The closest person to the transaction will see the full complexity of the transaction and its cost-effectiveness, but will naturally be myopic regarding the value of their program. The funder or advocate will see the big picture issue of trading off alternatives locations for spending a limited budget, but miss the on-the-ground complexity and hence the finer nuances seen by the practitioner.

Economic theory suggests that cost-effectiveness should be a useful factor in the allocation of public funds (Jenkins, Kuo, and Harberger 2011). There is no reason why EWT programs should be different than any other public investment. A low-risk low-payoff strategy of "advancing all the balls at once" by spreading funds across locations may seem equitable but may be inefficient from an environmental-economic perspective. A riskier, low-cost and high payoff strategy of "putting all your eggs in one basket" by piling funds into the most cost-effective location has merit but there are a number of potential pitfalls. In particular, such an effort needs to be carefully calibrated to pile funds on at the item that a program is ready to upscale. Otherwise piling on may simply increase transaction costs without a corresponding increase in flow transaction numbers or volumes. So the absorptive capacity must be present for the latter strategy to pay off. A positive, rational approach is to start with a strategy of spreading funds around and then as areas of high performance emerge concentrate the funding in these areas as they are ready to upscale and develop the staff capacity to absorb additional transactional dollars.

The point is that as existing EWT programs mature and spread from the Columbia Basin to other basins, particularly in the drier southwest region where water is more expensive and markets more developed (as in California), hard choices about where limited funds should be dedicated will require improved information on cost-effectiveness of EWTs.

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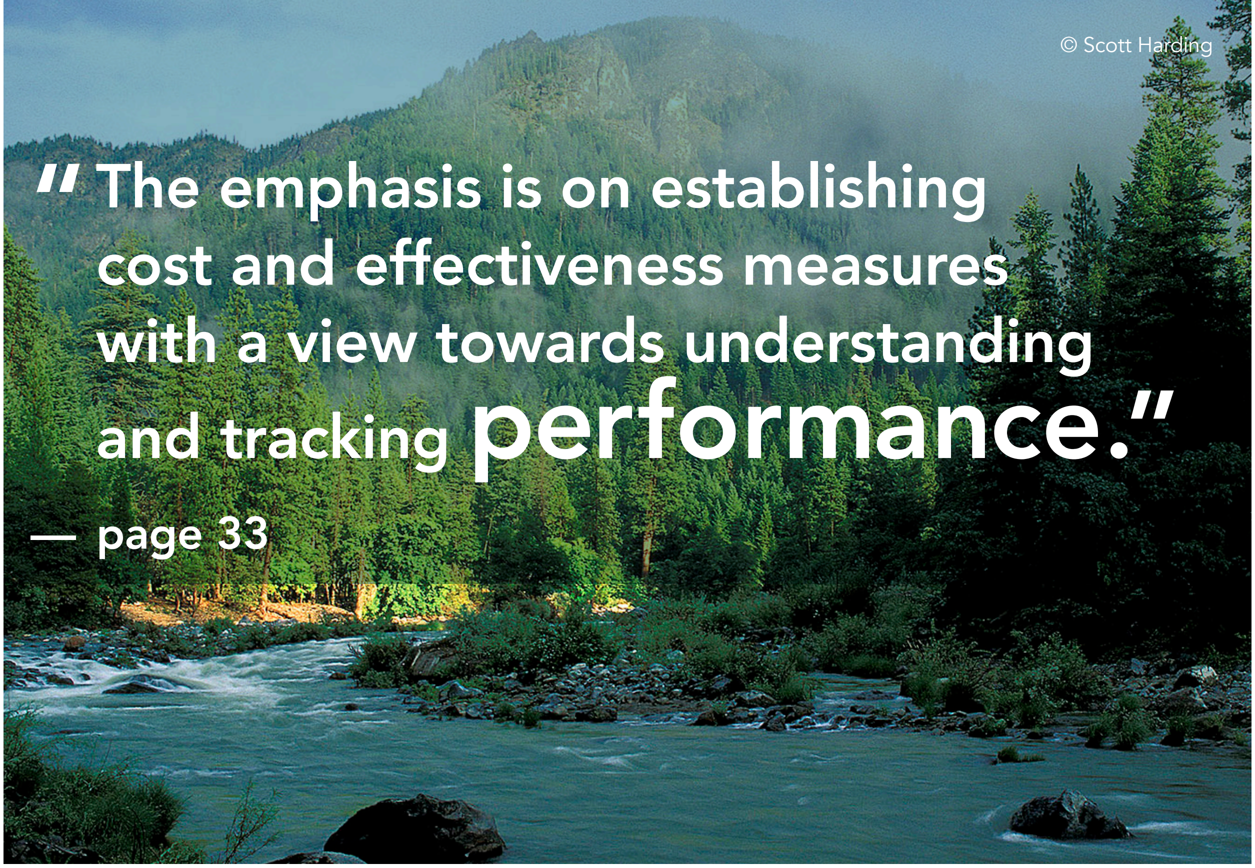

4. COST METRICS

Given the range of transactional approaches there are likewise a large range of costs that may need to be included as representative of the costs incurred. As per the discussion above we broadly separate these into water costs and transaction costs. There is nothing magical about the separation and indeed the line between the two may be blurry. But generally we consider water cost to be the direct outlay of funds to the seller in respect of their taking actions to put the water to environmental use. Transaction costs on the other hand reflect the costs of the effort and associated fees, supplies and services to develop, negotiate and implement the transaction.

4.1 A BRIEF DIGRESSION: WHY THIS IS NOT ABOUT ECONOMICS BUT ABOUT FINANCIAL INCENTIVES

In actual accounting for such costs it is important to understand that there is an implicit financial perspective that drives this accounting. Water costs and transaction costs as described below are largely accounted for from the perspective of the conservation buyer. Measures of costs and benefits to the economy of the transaction are beyond the scope of this analysis. This is important to understand so that there is no confusion about how this exercise relates to economic measures of well-being and/or non-market valuation studies of environmental flows. The latter can be important, but require another level of expertise, are often performed by academic researchers, and are much more time consuming and costly to carry out.

A traditional neoclassical economic evaluation of water cost would examine the marginal opportunity cost of the transaction to the economy. Take the case of a water use efficiency project in an irrigation district that is funded by a conservation buyer leading to increase environmental flows. The money paid by the buyer to the irrigation district as "payment" for the water could be regarded as the economic cost of the project, but this would be the most simplistic interpretation. More accurately this payment would be considered a financial transfer. Instead the evaluation would focus on the change in value of water use generated by the transaction and the costs of the infrastructure project. Since the project is a water use efficiency project there may be an implicit assumption that irrigation district agricultural production is unchanged, or the improvement in crop yield and or quality quantified and valued in economic terms. The additional water dedicated to environmental use presumably has some economic value. This value could be established through a non-market valuation study of the economic benefits of improved water quality, increased habitat and recreation value, etc.

Note that there is a further assumption here that moving the efficiency savings to an environmental use does not enlarge the water right or adversely affect other water users. If the transaction were to take water away from other users this would be an economic cost of the transaction. In effect, the function of injury review by the relevant authorities should reduce the chances of any unintended costs of this nature. Note similarly thought that if the transaction does not result in any additional environmental flows then there would be little economic benefits to the transaction. For example, if the saved water is just saved by the infrastructure installed by the district but not protected (or callable) to the former point of diversion or downstream by the conservation buyer, then the water may be diverted by another junior user. In this case there is no additionality to streamflow and no non-market impact to value.

The final piece of the economic evaluation would be to assess the economic costs of the water use efficiency measure. As pointed out earlier this might involve "soft" or "hard" design and implementation costs. The costs might all come up-front or might continue for years. Likewise the change in water use efficiency may have associated cost saving for the district in relation to its other operations and maintenance costs.

With a transaction that reduces irrigated acreage in the district, such as a transfer of water rights to environmental use, the set of costs changes. In place of the water use efficiency project costs would be the costs of the reduction agricultural production in the district.

When it comes to transaction costs of implementing transactions both seller and buyer will incur these costs. These should both be represented in an economic evaluation. But the transaction costs that we focus on here, and that are evaluated in other studies, are largely those incurred by the buyer (Garrick and Aylward 2012). In part this is due to the difficulty of measuring transaction costs in any comprehensive and consistent fashion. Where they are measured they tend to be derived from the buyers side of the programmatic costs incurred in running EWT programs. Another difficulty is that some transaction costs may in fact be represented by the payment from the conservation buyer to the seller. This may reflect mere reimbursement of fees and costs by the buyer or an implicit compensation to the seller of effort incurred in partnering on the transaction or project. Disentangling these costs is difficult and the effort is rarely expended to do so.

In other words in a full economic evaluation of costs and benefits the following would be included:

- the costs incurred by the irrigation district – not the amount paid to the district by the buyer;
- any production benefits from the transaction (if an efficiency project);
- the economic benefits of the increase or decrease in streamflow and associated economic values; and
- the transaction costs incurred by both buyer and seller.

This is not at all the same as what we propose below which is essentially the financial costs of the water to the buyer and, where possible, the buyers transaction costs. Water costs, as discussed here, are merely the financial incentives necessary to get the seller to engage in the transaction. So the exercise in this report should not be taken as passing any sort of judgment about the economics of EWTs. Nor does this report engage in a discussion of non-market valuation of environmental flows. The approach here is not an economic cost-benefit analysis. Rather it is a financial cost-effectiveness analysis. As such the emphasis is on establishing cost and effectiveness measures with a view towards understanding and tracking performance, with the motivation of improving performance, ensuring accountability of public funding for EWTs and promoting dialogue and understanding regarding cost-effectiveness in this field.

4.2 WATER COST

As noted the water cost of an EWT will consist of a financial transfer from the conservation buyer to the seller, usually an irrigator or irrigation entity. The buyer also might actually pay for and develop/install a water use efficiency project for the seller. In order to correctly account for these payments it is useful to specify the types of payments that might be made for the California EWTs discussed in Section 2:

- **Lease payment –** payment of funds to the lessor in return for engaging in a short- or long-term environmental transfer under 1707. For transfers of more than one year this payment may be made in its entirety at the approval of the transfer or at some regular interval (e.g., annually) based on performance under the transfer. The need to match payment to performance will vary with the risk taken on by the buyer and seller based on the terms and conditions of the lease agreement and the 1707 administrative change.
- **Forbearance payment –** payment of funds to the irrigator or irrigation entity. For fallowing agreements the payments would be similar to lease payments. For source switches the cost of implementing the sources switch including infrastructure, energy and operations and maintenance costs are likely to be the basis for the payment.
- **Water right purchase payment –** payment of funds to the seller in remuneration at closing either for the fee title acquisition of the water right by the buyer and/or the approval of the environmental transfer of the water right under 1707.
- **Exit fees –** payment to irrigation entities to settle all existing debt and future operations and maintenance obligations associated with a water right that is being transferred out of the entity.

These are broken out from the water right purchase payment as the one may be made to the irrigator and the second to the irrigation entity to which the irrigator belongs.

- **Conserved water payments –** payments to irrigators or irrigation entities for undertaking water conservation projects and subsequent environmental flows dedication. These may be determined on a cost per unit basis, i.e., a payment for the instream amount based on other projects or transactions, or simply all or a portion of the infrastructure and operations and maintenance costs of the conserved water project.

- **Land purchase payment –** payment by the buyer for the fee title acquisition of land, water rights and related interests.

- **Tax and assessments –** payment by the buyer of annual property taxes on land and annual irrigation entity assessments.

Collection of this water cost data needs to be on a transaction-by-transaction basis so that it can be associated with flows and other effectiveness data. The term of the transaction is a key piece of information and should reflect the number of years of environmental flows that are contracted for through the agreement. The year of expenditure of the funds needs to be recorded so that inflation adjusted costs can be calculated as part of cost-effectiveness measures. For some transactions payments will occur in successive years and it is important to record the total expended for each year, noting the year of the expense.

Transactions involving transfers tend to be less involved. For large infrastructure projects that generate conserved water it may be useful to record the total cost of the project and that portion that is paid by conservation buyers. In which case it is also useful to record the total water savings and that portion that is to be dedicated to environmental use.

For some transactions there may a number of funding sources. From a financing standpoint this information is useful, but it is not necessary for cost-effectiveness purposes.

Other accompanying data about the transaction may be recorded along with the cost. For example, for transfers it is normal to record the acres of water rights and for water use efficiency projects physical characteristics of the projects, such as lineal feet of pipe and the diameter of the pipe, may be recorded. These yield simply predictive measures of project costs such as cost per acre, or cost per lineal feet. While not cost-effectiveness figures in terms of environmental flows these indicators can be useful in projecting restoration budgets and discussing projects with irrigators and irrigation entities.

A simple table for recording water cost information is provided below.

Table 1. Water Cost Information by type of Transaction

Cost Item	Short Term	Split Season	Long Term	Water Purchase	Conserved Water	Land & Water Purchase
Transaction number						
Transaction name						
Transaction type						
Transaction term (no. of years for which water is acquired)						
Water costs						
Capital costs						
Water rights purchase				•		•
Long-term water rights payment			•			
Land and water rights purchase						•
Conserved water investment					•	
Recurring costs						
Payments for water	•	•	•			
Property tax						•
Irrigation assessments						•
Energy cost		•			•	
Operations and maintenance		•			•	
Transaction data						
Acres of water rights						
Acres of land						
Other (i.e. Lineal feet and pipe size)						

4.3 TRANSACTION COST

The primary ingredient in transaction costs will be staffing costs of the conservation buyer. In addition to that expenditure on filing fees, mapping, equipment, legal and engineering fees, and other specialized sub-contractors may be involved. Unfortunately, it is rare that these costs are allocated to specific transactions or projects at non-profit conservation buyers. In the study of transaction costs of EWT programs in the Columbia Basin, the authors therefore resorted to using programmatic figures and then using interview data with staff to allocate staff time and costs (Garrick and Aylward 2012). In that case the effort was to allocate staff time across the different tasks involved in transactions and across the watersheds in which the organization worked. Transaction costs were therefore aggregated at the watershed level and at the state level over a period of years and then compared to the volume and flow rates accomplished in these watersheds. In other words, these transaction costs were not expressed as costs by transaction or by type of transaction. The analysis found that high volumes and rates of environmental flows were associated with both low and high transaction costs across watersheds. The primary finding of the work was that transaction costs vary across states and within state, therefore suggesting that investments in policy reform (to enable transactions) which occurs at the state and local level can achieve increasing returns to scale over time (Garrick and Aylward 2012).

The Columbia Basin Water Transactions Program, implemented by the National Fish and Wildlife Foundation, includes a question on its transaction form asking for an estimate by the practitioner of the transaction costs of developing the transaction being submitted. This is one approach, i.e. to directly ask the applicant requesting funds about the transaction costs. To date this data has not been examined in detail, in part due to the difficulty of having no benchmark against which to evaluate the estimates.

There are at least three difficulties associated with this direct approach as implemented by NFWF:

1. There is no listing of what transaction costs should be included. Conservation non-profits often spend time on a range of activities some of which are directly related to transactions (such as negotiating with a landowner) and some are not (such as attending a farm fair, or participating in policy processes), so an understanding of what is and what is not a transaction cost is missing. A listing of items that qualify would be a remedy to this problem.

2. There is no standard method provided for apportioning costs that are shared amongst projects.

3. The questions are asked at the funding stage but there is no follow up to review and confirm transaction costs once the transaction is completed.

As importantly, the use and consequences of the figures filled in on the form are not clear to the respondents. As a result of all of these issues the transaction costs are likely to be very crude estimates.

The direct questioning approach, however, may be a useful one if some of the issues raised above are to be addressed more formally. Provision of a table with set categories of costs to jog the respondent's memory would be helpful. Of particular importance is the problem of disaggregation and aggregation. In asking the direct question of staff it will be necessary for staff to allocate a portion of time and other costs to the transaction. In order to arrive at a consistent measure of transaction costs then it would be advisable to re-aggregate back to total transaction costs for the period and compare to actual program costs to make sure that the appropriate portion of program costs is represented as transaction costs. One alternative then is to ask for transaction-by-transaction information but then also each year ask for an allocation of the organizations yearly expenditures to transactions, or at least that portion of the organization's expenditures that are related to environmental water transactions.

An indicative table of information that could be used to record transaction costs is on page 37.

Table 2. Transaction Cost Information

Cost Item
Transaction Number
Transaction Name
Transaction Type
Transaction Term (no. of years for which water is acquired)
Staff costs
Hours by staff
Salary by staff
Fringe/Benefits by staff
Professional Services and Consulting Fees
Engineering, Hydrology, Biology, etc.
GIS, Mapping, Water Rights Examiner, etc.
Legal Fees
CPA, tax advice
Appraisal - Water or Land
Travel
Staff travel
Contractor travel
Supplies and Fees
Maps
Printing
Water Right Fees
Recording Fees
Escrow Fees
Other Supplies and Fees
General & Administrative
Indirect Expenses (as % of other costs)

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5. EFFECTIVENESS METRICS

EWTs may be designed with any of a broad suite of environmental benefits in mind. Generally the progression of outcomes can be stated as physical, chemical, ecological and biological. As discussed earlier these outcomes obviously have social and economic value but here we focus on the environmental outcomes. The transaction's direct impact is to increase instream flow or the provision of water to an out-of-stream environmental use, such as habitat watering, wetlands, etc. Indirect impacts cascade from that point forward. For rivers running to the Pacific Ocean restoring habitat for anadromous fish is often an explicit goal of EWTs in dewatered systems. Here the added flow may aid in the upstream passage of spawning adults, the provision of additional spawning and rearing habitat, and the downstream passage of juveniles. In the Great Basin and in the Colorado River Basin, EWTs may be aimed at restoring the water quality balance (e.g. total dissolved solids of rivers) of rivers, terminal lakes and estuaries to support for fish and wildlife populations. There is a broad range of goals and outcomes from EWTs and thus assessment of effectiveness will likewise vary from location to location.

5.1 POTENTIAL EFFECTIVENESS METRICS

Despite the growing number of water transactions designed and implemented for environmental purposes, limited effort is devoted to assessing and tracking outcomes from flow transactions (Davies et al. 2013). This imbalance between implementation and assessment of effectiveness arises from multiple factors, including the high costs of long-term monitoring and limited project budgets. As a result, critical knowledge gaps remain around the relationships between transactions, flow restoration, ecological responses, and biological communities.

These knowledge gaps are receiving significant attention in the Columbia River Basin. Throughout the basin, the magnitude and scale of efforts to revive salmon runs are considered to be unprecedented in U.S. history (Barnas & Katz, 2010). Between 2001 and 2003, nearly $400 million federal dollars per year were directed towards rehabilitating the Columbia River Basin (Rumps et al 2007). However, comparatively little is known about the effectiveness of these endeavors, both as individual projects and cumulatively (Willis et al. 2016; Barnas et al. 2015). Several significant large-scale monitoring efforts have been developed to bridge these knowledge gaps, including the Columbia Habitat Monitoring Program (CHaMP), the Pacific Northwest Aquatic Monitoring Partnership (PNAMP), Northwest Power and Conservation Council's Columbia River Basin Monitoring, Evaluation, Research and Report Plan (MERR), and the Integrated Status & Effectiveness Monitoring Program (ISEMP), among many others. Website links for these programs are provided in the resources section later in this chapter. Each of these efforts has based its monitoring plans on three general categories of monitoring actions (NPCC 2010):

Compliance and Implementation Monitoring. These monitoring activities track the extent to which the steps of a plan have been carried out, or the degree to which established laws, rules, or requirements have been met.

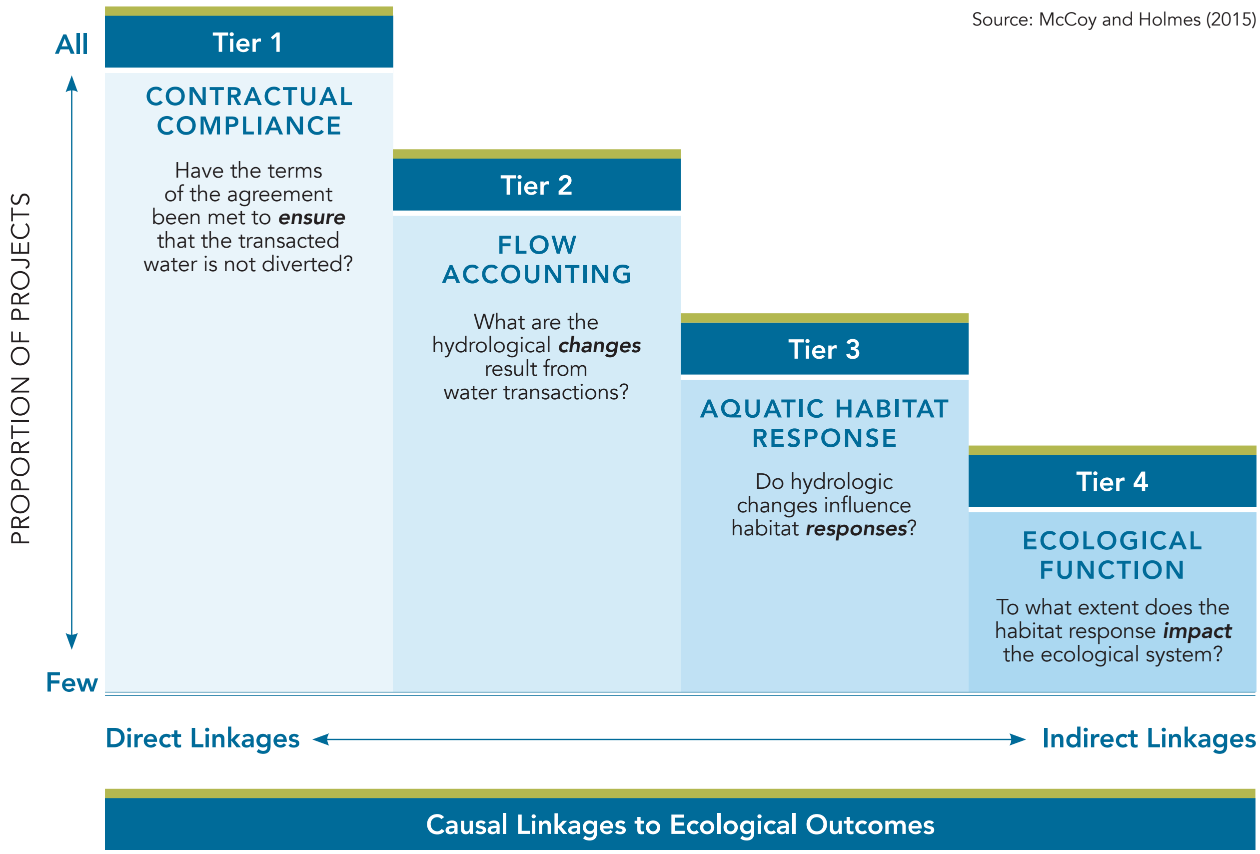
Status and Trend Monitoring. These efforts characterize existing conditions that serve as a baseline and documents changes in conditions, stressors, or responses over time as compared to baseline conditions. Status and trend monitoring does not necessarily determine the causes of observed results.

Effectiveness Monitoring. There are two types of effectiveness monitoring. Project scale effectiveness monitoring measures environmental parameters to determine if activities were effective in creating a desired change in habitat conditions. Action effectiveness monitoring endeavors to establish "cause and effect" relationships between biological population dynamics, habitat conditions, and management actions.

From the perspectives of water transactions, knowledge gaps remain around documenting direct relationships between flow alteration and targeted biota. Recent research supports this challenge in showing that community and process-based physical and biological indicators do not respond to changes in the flow regime in predictable ways and are therefore difficult to track and monitor (Poff and Zimmerman 2010).

With these cause and effect challenges acknowledged, the flow accounting framework provided by NFWF and Ecosystem Economics as part of the CBWTP program is a useful starting point for thinking about effectiveness metrics for EWTs (McCoy and Holmes 2015). The program takes a tiered approach to assessing the effectiveness of EWTs by examining contractual compliance, flow accounting, aquatic habitat response, and ecological function in successive iterations (as explained in Box 1). The underlying proposition (as shown in Figure 2) is that it will not be useful (or cost-effective) to monitor and evaluate each transaction on all four tiers. Instead various criteria (e.g. size and cost of the transaction) may trigger monitoring to proceed to additional tiers. While effectiveness monitoring is an essential component of any restoration program, the targeted focus of water transactions as a restoration tool makes it difficult and resource intensive to trace ecological and biological changes that result specifically from augmented flows. Therefore, the CBWTP framework is built around ensuring contractual compliance and tracking hydrologic and ecological changes over time as a result of increased flows. As we shall see these arguments will also drive our selection of cost-effectiveness metrics.

Figure 2. CBWTP Tiered Accounting Framework for EWTs



BOX 1. CBWTP'S FLOW ACCOUNTING TIERS

Tier 1 | CONTRACTUAL COMPLIANCE – Requirements for Tier 1 ensure that the legal terms of the contract between the QLE and water user are fulfilled and met accurately. All transactions are included within Tier 1 and must fulfill reporting requirements as defined by the transaction type (e.g., lease, purchase, split-season). Each type of transaction has a specified set of monitoring criteria, and depending on the type of deal, requires demonstration of compliance annually. Tier 1 can also account for flow added to the protected stream reach at the POD for transactions that rely upon flow as part of the contract, as is the case for minimum flow agreements. In this case, flow is monitored in order to implement the transaction. However, flow monitoring in this tier is not intended to track the degree to which flow targets or goals are reached. That type of effectiveness monitoring is part of Tier 2 and does not focus on the evaluation of whether the terms of the contract were sufficiently met.

Tier 2 | FLOW ACCOUNTING – Tier 2 accounts for the flow added to the protected stream reach from the POD along the specified length of the protected reach before, during, and after the period of ecological significance, as defined by the objective of the transaction in addressing the key limiting factor of flow for identified and targeted species. Monitoring under Tier 2 can also be used to track progress towards flow goals and/or targets.

Tier 3 | AQUATIC HABITAT RESPONSE – Transactions that fall within this tier must track changes in flow-related limiting factors by accounting for aquatic habitat metrics along a specified section of the protected reach during the period of ecological significance. This period is defined by the objective of the transaction in addressing key limiting factors that are unique to the location and purpose of the transaction. A monitoring and accounting strategy will be required for each transaction placed within this tier.

Tier 4 | ECOLOGICAL FUNCTION – This tier integrates transaction and flow-specific monitoring data gathered in Tiers 1, 2, and 3 with broader monitoring efforts in priority regions throughout the Columbia Basin. Monitoring efforts in this tier will be structured in specific basins where CBWTP transaction and other local monitoring efforts overlap to evaluate changes in flow-related habitat characteristics that are examined within the context of broader-scale biological conditions and, where possible, fish population dynamics.

Source: McCoy and Holmes (2015)

5.1.1 FLOW & WATER BENEFITS OF TRANSACTIONS

Environmental water transactions are deployed to improve streamflow and provide water to environmental uses. Thus, the most basic effectiveness measure will relate to the flow and water provided by these transactions. A listing of the typical metrics used to measure and evaluate the flow benefits of EWTs includes:

- the volume of water dedicated to environmental use (measured in acre-feet or AF);
- the rate of water dedicated to environmental use (measured in cubic feet per second or cfs);

- the time period that the transaction is in effect and the flow/water is provided (e.g. the days or season of use as well as the duration or term of the transaction in years);
- the reliability of the water right, which is based on the relative seniority of the priority date on the water right;
- the miles of stream reach receiving additional water;
- the period of time during an ecological period of significance or other period of critical importance; and
- a hybrid percent of flow metric such as % of existing flow, % of natural flow, % achieved towards the gap between existing flow and a streamflow target.

For the first two metrics, the relationship between flow rate and flow volume is simply the duration of the flow rate. In this sense it may help to understand that the flow rate or cfs is actually a flow rate in volume terms (cubic foot being a volume). Thus the first three metrics above are interrelated mathematically. The flow rate over the time period results in a flow volume (1 cfs for 1 day equals 1.9835 acre-feet). The reliability of the water right expresses a probability for the flow rate by time period (down to the day). So the reliability applied to the flow rate over a given time period results in an expected reliable flow rate and an expected reliable volume. Reliability is discussed further in the next sub-section. These four metrics are interrelated and are fundamental to any flow/water metric.

The miles of stream that are rewatered is another simple indicator that may be easily estimated. However, it does not in and of itself convey much meaning. A flow gap for a short distance may be just as important ecologically as a long stretch of flow gap. Without additional ecological information this metric is of little value.

The period of ecological significance metric is a proxy of sorts for higher-level habitat and ecological benefits as it extracts the truly "additional" reliable water that a transaction will provide that is of ecological significance. Finally, hybrid metrics may be constructed that deploy the incremental flow increase due to a transaction relative to another variable. So the percent increase in flow is one such metric. However, this tells little about progress towards an objective. A better performance metric is then measuring the distance achieved towards a flow target, for example. In this case the % of remaining flow needed to meet a target is one measure, or more simply the % of the flow target represented by a transaction.

5.1.2 RELIABILITY

Reliability of the water right underlying an EWT is a critical element of the transaction. A junior right means infrequent fulfillment and fulfillment only when there is already a lot of water in the system. A senior right means frequent fulfillment and fulfillment in dry periods when there is not much water available. Depending on the purpose of an EWT program either or both types of rights may be desirable. Typically, however, the goal is to vastly improve on the environment's standing as the residual or most junior (where there are environmental rights) user in the system. For this reason, most EWT programs will prefer water transactions with senior water right holders. By doing so this improves the probability that the resulting transactions will provide wet water in a given year and over time.

When transactions are in implementation and streamflow is monitored the level of streamflow can be observed. Understanding whether the water associated with the EWT may be simple or hard to do. If the reach is usually dewatered in a normal year and it is a normal year and flow is present it is a logical assumption that the flow is from the transactions. This is even more obvious if there is a call on the water right(s) for that reach that can be clearly observed. If the flow is not equal to the call then the presumption is that only X percent of the water rights being called on are in priority. This should also be observable with respect to out-of-stream water rights that are diverted at that time.

Unfortunately, this is the simplest case and there are many others where it is possible to measure flow in the stream but it may not be clear why the flow is present or whether the flow associated with the EWT, as opposed to other downstream rights, return flows or excess flows is actually present in the stream. Thus, ex-post assessment of flows resulting from transactions, through monitoring, may be relatively simple or more complex. Of course, it is always necessary to first measure flows at an appropriate point in the reach of interest. In other words, flow monitoring of some kind (using continuous gaging, manual gaging or other approaches) is a necessary, but not always the only information needed, to assess the effectiveness of a transaction in terms of flow.

In assessing potential effectiveness of a transaction before implementation there is a need to estimate the probability that the transaction will result in wet water. This is a very different problem from the monitoring problem. Essentially, the estimate will rely on some set of historical observations and/or modeling of supply and demand for water in the pertinent reach. Methods for this include, amongst others:

- complex water distribution models (i.e., Modsim, Riverware, etc.) to estimate future water yield;
- historic watermaster records of when water rights are in priority to estimate future water yield;
- simple water allocation models based on demand (from water rights and their priorities) and water supply (from historic records) to calculate likely water yield; and
- rule of thumb figures provided by water users, the watermaster or other informed sources.

Obviously, a water right that is known to be interruptible should be subjected to some form of analysis or otherwise discounted before flow and volume figures are used in a cost-effectiveness analysis.

5.1.3 HABITAT AND ECOLOGICAL BENEFITS OF TRANSACTIONS

Using environmental water transactions as a restoration tool requires monitoring at multiple scales including at the site, stream, habitat, and species levels. Regardless of the scale of focus however, it is critical to design a monitoring plan that tracks the influence of the restoration action (in this case flow augmentation) on well-defined habitat needs for target aquatic species (Barnas et al. 2015; Katz et al. 2007). There are a number of potential effectiveness measures that can be tracked before, during and after transaction implementation to make the connection between the restoration actions and improvements in impaired conditions, including:

- physical habitat, for example:
  - an increase in stream habitat which could be measured by the wetted width of the stream, and/or
  - expanded spawning habitat which could be measured by counting spawning sites;
- water quality, as measured by concentrations of total dissolved solids in a river or lake;
- fish passage, as evidenced by an increase in the counts of fish passing through a given restored stream reach;
- aquatic species survival within a stream reach or delineated habitat area as determined by fish counts; and
- aquatic species population.

Note that as with flow monitoring, monitoring of these habitat and ecological benefits requires knowledge of the "before", as well as "after", situation in order to assess the marginal effectiveness of transactions in the affected reach. And just as with pre-project efforts to estimate flow/water effectiveness there are a number of habitat simulation models to capture complex dynamics and feedback loops that are influenced by flow variation at larger ecological scales (Anderson et al. 2006). Several methods are extensively utilized by state and federal agencies to establish standardized methodologies for species restoration and management. The most common methods used in the Pacific Northwest include the Instream Flow Incremental Methodology (IFIM) of which the Physical Habitat Simulation (PHABSIM) model is one particular method. IFIM methods are designed for use in predominantly perennial systems to model the impact of instream flow variations on specific life-stage needs of various aquatic species (Petts 2009). PHABSIM is an IFIM approach intended to create weighted usable area curves that correlate physical stream characteristics (e.g. velocity, depth, and substrate) to fish density through an index of habitat preference (Bouwes et al. 2011). PHABSIM is not necessarily a suitable approach for monitoring transactions in smaller stream systems. PHABSIM models need to be recalibrated every time there is a significant change in channel form in order to be accurate at a site-specific level, which can be extremely expensive and time intensive. PHABSIM models are not particularly well suited for most coastal California streams and many tributaries streams along the Sierra which have channels with high width-to-depth ratios and high sediment loads that have pulse releases during annual storm events (Alford, pers. comm. 2016).

5.2 CONSTRAINTS ON EFFECTIVENESS METRICS FOR USE IN COST-EFFECTIVENESS

In discussing effectiveness here it is important to keep in mind that the objective here is not effectiveness monitoring and evaluation writ large, but rather elaborating effectiveness metrics that can serve in the cost-effectiveness analysis of transactions. While these might seem to be the same thing they are not. There are three conceptual questions that illustrate the issues involved in deploying effectiveness metrics to the purpose of cost-effectiveness:

1. **Scale:** Transaction by transaction effectiveness versus reach or program effectiveness.
2. **Timing:** cost-effectiveness during transaction development and/or implementation (pre-, during and post-project).
3. **Practicality and replicability:** the degree to which metrics are amenable to reliable quantification.

We address before turning to a listing of potential effectiveness metrics for cost-effectiveness analysis

SCALE.

At the outset of a flow restoration program efforts are often devoted to strategizing around a program of flow transactions to address environmental needs. Ideally this phase is not protracted given that once efforts to implement begin the focus quickly turns away from the "optimal" transaction to the feasible transactions. In the initial stages of implementation then it may seem like the objective is simply to do a transaction, or as it is said by practitioners to "do deals." However, once proof of concept for various transactions is achieved the focus may turn from an opportunistic approach back to a more strategic and planned focus on a program of flow restorations designed to meet flow targets in specific stream reaches. Ideally, these targets are in turn linked by the best available science to the desired chemical, ecological and biological outcomes. In very small tributary streams a single transaction with a single landowner might be enough to meet the target. But as you move further downstream the targets are unlikely to be filled by a single transaction. There is then the problem of measuring effectiveness per transaction as opposed to for the full set of transactions in place.

The effectiveness of an individual transaction presumably makes some marginal contribution toward the reach outcome. But the path from dewatered reach to reach with target met is unlikely to be linear with respect to additional units of flow. So the scale issue raises questions of how to address incremental benefits of individual transactions. Should these be the marginal contribution (in order of implementation) or should they be the average contribution across flow transactions in effect at a given time. The only thing that can be said is that all transactions in place at a given time add up to the cumulative benefit. Effectiveness monitoring is therefore likely to focus on the cumulative benefit of an aggregate of transactions at any given point in time.

This implies that in order to assess cost-effectiveness of individual transactions it is necessary to find a metric that can be easily and assuredly associated with transactions on a transactions-by-transaction basis.

TIMING.

Cost-effectiveness of transactions is useful information at the stage where a choice is made between alternative transactions. This would be at the program planning stage or at the decision to submit one or the other transaction for funding. Neither the cost nor the effectiveness of transactions is known with certainty at this stage, rather there will be estimates of what these will be for the transactions. By example, a key element in effectiveness of a flow transaction is the frequency with which the transaction will yield actual water instream, i.e. "wet" water as opposed to the "paper" water on the certificate. Historical reliability of water rights on the system is typically used to estimate the expected wet water yield of a transaction. A one-year lease provides only one year to make good on the right. It might be a poor or good water year. If it is a poor water year the effectiveness of the transaction measured at the end of the year will typically be lower than expected, unless the right is the most senior on the system. Estimated prior to the transaction the expected effectiveness of the transaction would be substantially higher, reflecting the average, median or other statistic used to compute expected reliability and hence effectiveness. Of course, there are various ways to lay off this risk. For example contracting for payment only for the wet water actually realized on a lease would be one solution. Alternatively, this risk may play into the comparison of the cost-effectiveness of short- versus long-term transactions as with the latter the risk is muted by the duration of the transaction and the continual "re-sampling" of the hydrograph. A risk adverse buyer might pay a premium for a long-term transaction on these grounds.

The point is that the expected pre-project effectiveness may well be different than the post-project effectiveness. If cost-effectiveness metrics are to be used in planning and selection the effectiveness metric should be one that is as robust as possible to estimate before actually undertaking the transaction.

PRACTICAL AND REPLICABLE.

Along with scale and timing, the effectiveness metric must above all be practical and replicable. EWT practitioners are not academics or scientists with time to research complex problems. The metric must be practical. The more time it takes to compute an effectiveness metric the less likely that it will actually be computed. The metric must be replicable. In order for cost-effectiveness metrics to be useful in transaction planning and selection they must be comparable. This means that the effectiveness metric for different transactions on the same reach cannot be different metrics. Ideally they must be the same metric (and in the same units) or they are not comparable. If they are in different metrics than the relationship between the two metrics must be able to be inferred once they are set against costs. For example, if cost-effectiveness for one transaction is measured as a dollar per unit volume of water per year this can be set off against the metric for a second transaction that is expressed in terms of dollar per unit volume of water during the critical time period for flow in a year (based on species need). For example, if the cost per unit of flow during the critical period is equal to or less than the cost per unit of volume of water during the whole year than the second transaction would clearly be favored. Such cases though would seem to be rare based on experience.

The main point then is that since cost-effectiveness metrics are used in comparing alternatives, this requires that the effectiveness metric be practical and replicable across the universe of transactions for which a cost-effectiveness analysis is desired.

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6. COST-EFFECTIVENESS METRICS FOR ENVIRONMENTAL WATER TRANSACTIONS

In this section we explore potential cost-effectiveness metrics and select a flow/water cost-effectiveness metric as a basic metric, to be supplemented when useful with more complex and site-specific % of flow, habitat or ecological metrics. We then proceed to address a series of methodological issues in deriving the basic cost-effectiveness metric.

6.1 SELECTION OF COST-EFFECTIVENESS METRICS

The closing sub-section above sheds light on a number of issues surrounding the potential utility of the various effectiveness metrics as inputs to cost-effectiveness analysis. There are a range of potential cost-effectiveness measures that may be deployed once the cost and effectiveness metrics are combined:

- $/cfs;
- $/acre-foot;
- $/increment to target metric;
- $/increment of habitat benefit; and
- $/increment of ecological benefit.

As stated in the previous section, the fundamental needs for cost-effectiveness information suggest that the effectiveness metric must be practical and replicable and applicable to individual transactions at the pre-project stage. This will argue for a basic cost-effectiveness metric that can be derived:

- for individual transactions and for groups of transactions (in a reach);
- before and after the project; and
- by the practitioner, i.e. they cannot be costly or time-consuming to generate.

Within a given geography, where the information on habitat and ecological responses to flow/water is available in some predictable and standardized form then a flow/volume water metric is the simplest and most replicable approach. For example, for floodplain restoration the response of a particular type of habitat (such as a willow-cottonwood mix) may be well known. The cost-effectiveness metric could then be expressed in a cost figure per acre of functional willow-cottonwood habitat. Of course if the objective is to provide information on the cost-effectiveness of various transaction types in fulfillment of this ecological outcome then translating the cost-effectiveness metric from $/acre-feet of water to $/acre of habitat does not really improve decision-making. Presumably for a given increment of water the water to habitat relationship is the same, so whether cost-effectiveness is expressed in terms of volume of water or acres of habitat the relative ranking of projects will not change in going from one to the other. It may be worth emphasizing that just examining projects based on total costs would not be useful either. There does need to be an effectiveness metric associated with the cost in order to correctly rank projects in terms of cost per unit output.

Practicality and replicability argue for using the physical metrics for flow/water as the effectiveness metrics in a basic cost-effectiveness metric for general application, i.e., across years, programs and geographies.

Obviously such a simple metric begs two important questions. First, as additional units of flow are added to the system the ecological response may vary. In other words the flow/ecology relationship is unlikely to be linear from a totally dewatered state through to restoration of natural flow. This means that the same dollar cost per volume of water transaction at one point in the curve will not be of the same cost-effectiveness as at another point in the curve. Understanding the shape of the flow/ecology curve (roughly linear or increasing/decreasing at inflection points) as well as the shape of cost-effectiveness curve (are inflation adjusted costs increasing over time) can be useful in interpreting the results of the basic cost-effectiveness metric with respect to non-linear flow/ecology relationships. This applies for comparison of transactions within a given reach of a stream, as well as comparison of transactions in different locations.

A more serious issue is that a given amount of flow or water in one waterway will not be as effective in restoring flow, habitat, ecology or populations as in another. There is therefore a role for a dollar per increment measure towards a flow target, habitat or other ecological goal.

For example, if there are two distinct geographies, both with a need for improved willow-cottonwood habitat then the use of an increment of habitat indicator may be of value. This, as the relationship between water and habitat between the two sites may differ. If it is the same relationship then again the $/acre-foot metric is sufficient. But if due to elevation, climate or some other relationship a unit of water in one location generates more acres of habitat then expressing effectiveness in habitat terms will better assist those involved in allocating funds to compare and contrast the value of investments in the two areas.

Similarly, one cfs in one location may be all that is needed to ensure fish passage, while in another 500 cfs may be necessary to maintain flow-dependent species habitat. A transaction of half a cfs is therefore 50% of the way towards the objective in the first case, but a mere drop of water in the latter case. The use of a dollar per % increment towards target would therefore rate such a transaction very differently in the two cases. While this is generally true it may be useful to consider that smaller systems might generally be assumed to produce smaller ecological benefits. So there may also be a scaling in that in the case of the one cfs fish passage there may not be many fish passing through; whereas the 500 cfs system might be maintaining a much larger expanse of habitat and supporting larger numbers of species and individuals. Then again, the uniqueness of those few fish passing through the small 1 cfs channel may make them of much higher ecological value. As per the discussion with habitat above the only way to truly weigh in on these issues is to calculate these more advanced cost-effectiveness metrics. It is useful however, to recognize that ultimately, beyond the numbers and metrics, the importance of habitat and ecological benefits are a subjective matter. Even if advanced cost-effectiveness metrics, such as dollars per ecological increments, can be derived they will still be difficult to compare one with the other as that means trading off different ecological benefits with each other. Providing even basic cost-effectiveness data can therefore be a useful, objective counterweight to such metaphysical discussions.

In specific cases the use of increment to flow target, habitat or ecological metrics is ideal, but these are likely to be context dependent and limited in applicability; and further they may be just as hard to use in cross-site comparisons.

With respect to flow/water metrics for use in cost-effectiveness analysis there still remain a question of what is sufficient and which metric is the most desirable. This relates to reliability and the distinction between a flow and a volume metric. These are pursued in the next two sub-sections.

6.2 RELIABILITY: THE PROBLEM OF COUNTING WET WATER

With respect to reliability it seems insufficient just to express the cost of a transaction in units of paper water. Yet pretty much every large data set of water transactions, not just environmental transactions, comes without reliability information. For example, probably the most comprehensive data set for water market transactions was compiled from Water Strategies and other sources by a number of economists (Brewer et al. 2007). There is no reliability information associated with the quantities in this study. To their complement the authors refrained from attempting to present any cost-effectiveness metrics in their overview paper.

Another example would be the CBWTP suite of transactions. From 2003 to present the program has engaged in over 400 different transactions (McCoy and Holmes 2015). In proposing transactions for funding, applicants are asked a series of question about the underlying water rights, including specifying the priority date of the right. Applicants are asked the fundamental question of whether the originating right is typically satisfied. This is a yes/no question. Applicants are then asked about the flow and volume expected under the transactions. They are asked about the maximum flow rate and volume that will be realized under the transaction. They are asked if this maximum rate will vary and if so by how much. They are also asked if the maximum volume will vary during the duration of the transaction. They are then asked about the amount and timing by which this amount will vary. Applicants are not actually asked to specify an average flow rate or an average volume for their transaction over the life of the transaction. It is worth noting then that CBWTP applicants are not asked as to the expected wet water from the transaction.

These two examples highlight how broad conversations across geographies about $/cfs or $/acre-foot for water transactions need contextualizing, as the water that is being talked about may not all be wet water. There is therefore room for improvement on this front. To some extent this is why this report recommends working on cost-effectiveness metrics in flow/volume terms. Even this basic information is not routinely collected in any standardized fashion in large datasets about water transactions or on applications for public funding to conduct EWTs. It is also worth emphasizing, that the determination of reliability (or estimating wet water) is something that can only be done at the site level. A centralized analyst far away in a capital city is not in position to estimate the reliability of a series of transactions that come from a range of different watersheds and reaches with a variety of priority dates. Ideally, such information would exist in a central database for each state, but it does not. In the meantime a standardized yet flexible method of eliciting this information from those working in each geography is needed. One way this could be accomplished is by requiring an overall analysis of reliability for water rights in a watershed as a precondition for participating in an EWT program or funding cycle. This might require the funder or program to provide financial assistance or methodological assistance for this purpose.

Wet water will be the appropriate metric for measuring cost-effectiveness, but may involve approximations of various degrees of accuracy.

6.3 FLOW RATE VERSUS WATER VOLUME

The duration of a transaction within the water year is a defining characteristic of the transaction. All transactions provide a flow of water that is measured as a flow rate (e.g., in cubic feet per second). A transaction results in this flow rate being provided for environmental flow over some period of time (usually counted as days). A transaction providing one cfs of flow for one day yields a water volume of 1.9835 acre-feet (AF). The question is when we count the benefits of the transaction is it best expressed in flow rate or water volume terms. How would you compare a 20 cfs transaction with a 2,400 AF transaction? Without knowing the number of days associated with one or either of the transactions you cannot tell which one produces more water for the environment. A 2,400 AF transaction over 60 days provides a flow approximately equivalent to a 20 cfs transaction. So if the 20 cfs transaction is only for 30 days it produces 1,200 AF. If the 2,400 AF transaction lasts for 120 days it provides 10 cfs of flow during this period. One transaction provides more cfs but for fewer days, the other provides fewer cfs but for more days. Which is better?

Under the assumption that all the flow provided by the transaction meets an established flow need the simplest and recommended approach is to use the volume measure or acre-feet. The advantage of the volume measure is that can be compared to the entire flow need and provide a clear indication of progress made toward this need. If the flow rate were used it would only meet this objective if the flow rate were for the entire period. Securing 20 cfs for 30 days towards a 120-day need of 40 cfs provides an unclear measure of progress. In fact the benefit can be measured, but it would simply be to proportion the extent to which the 20 cfs meets the larger objective. Since this is essentially the same as calculating the additional volume generated by the transaction it is just simpler to use the acre-foot figure.

And, finally, layer onto this discussion the issue of reliability. Unless the underlying water right is senior to all others the rate actually realized under a transaction may vary across the season of use that is transacted. In other words, in our example above, the 20 cfs might actually be 20 cfs one day and 10 cfs the next day. Again, subject to our assumptions it makes more sense then to add the 20 cfs to the 10 cfs and this means effectively adding daily volumes of water realized under the transaction.

The dollars per volume of flow should be the primary basic cost-effectiveness metric.

6.4 VOLUME VERSUS CONTRIBUTING VOLUME OR CRITICAL PERIOD VOLUME

For cost-effectiveness analysis to be useful we want to be comparing like with like in terms of effectiveness. This is where the concept of additionality and the period of ecological significance arise. In order to warrant the expenditure of scarce conservation dollars the EWT should be providing additional flow/water that meets an established need. An established environmental flow need exists when studies have shown that a certain flow amount or flow range is beneficial for environmental purposes, whether for fish, wildlife or other purposes as discussed earlier in this report. If the need is already met, and the transaction provides flow on top of the target flow, this is not to say that such flow does not generate benefits. The question is whether that additional flow should be included as a benefit in the cost-effectiveness calculation. Arguably all units of flow are not created equal. The purpose of establishing flow/water targets is to define the environmental flow need. Once that is done, the flow generated by transactions should be measured against these targets in measuring the flow benefits for comparisons of cost-effectiveness.

Wet water counted as a volume benefit should be water that contributes to meeting an established flow need.

A variation on this approach occurs when there is a period of critical ecological significance. Typically this would be a period of time during which a flow target is of exceptional value for environmental purpose. For example, in the critical period for fish in our example above is the 30-day period that the 20 cfs transaction provides flow then we might not want to ascribe the same effectiveness to the other 90 days of flow provided by the second transaction (the 120-day transaction). In this case we may want to draw attention to the cost-effectiveness of these two transactions in meeting the critical period need. If both transactions cost the same amount of money per acre-foot of water acquired, then the shorter transaction is going to look much more cost-effective. As explained below, given the assumption of the same underlying dollar per acre-foot cost, the 120-day transaction costs four times as much in producing critical period water as the 30-day transaction.

(For example at $1,000/AF the 10 cfs, 120 day, 2,400 AF transaction would cost $2.4 million and produce 600 AF of water during the 30-day critical period for a cost-effectiveness of $4,000/AF. The 20 cfs, 30-day, 1,200 AF transaction would cost $1.2 million and produce 1,200 AF during the critical period for a cost-effectiveness of $1,000/AF. The longer transaction costs four times as much for critical period water)

6.5 MEASURING COST-EFFECTIVENESS OVER TIME: COMPARING TRANSACTIONS OF DIFFERENT DURATIONS

A final issue in cost-effectiveness relates to both costs and effectiveness. For transactions that occur in different time periods there is the problem of how to account for price inflation. For transactions that have different durations and expenditures occurring in different periods there is the further issue of how to account for the time value of money. In other words we may be comparing transactions where money has been spent in a number of different years, so the value of the money spent is not directly comparable, and/or we have costs and benefits occurring over different periods of time so we need to account for the opportunity cost of capital and the social rate of time preference.

6.5.1 ADJUSTING FOR PRICE INFLATION

For example a one-year lease in 2013 might cost $100/AF. In 2014 it might cost $110/AF. Is the transaction in 2013 more cost-effective than the transaction in 2014? Well, the economic answer is that it depends. First, it depends on the movement of the general rate of price inflation. If the average increase in the general price index were 10% between 2013 and 2014 then $100 in 2013 money would be equivalent to $110 in 2014 money. The cost-effectiveness of these transactions would be the same. So we need to adjust funds expended in different years to remove the myopia of what are called nominal prices, and instead use inflation adjusted, called "real" prices.

Of course the price of water may be increasing at a rate that is higher or lower than the general price level. If for example the rate of inflation between 2013 and 2014 is not 10% but rather 5%, the cost of the water in 2014 will be higher once the inflation adjustment is made. In point of fact, the cost of the lease in 2014 will be 5% higher in real terms. In this case then the price of water is growing at a real rate of growth of 5%. A real rate of growth just means with respect to the general rate of price inflation. When current prices (i.e., nominal prices for a given year) are adjusted to real prices, we say they are put in constant dollars, i.e., dollars of a specific base or reference year.

There are, naturally, a number of measures of price inflation. To keep the analysis as simple as possible we recommend using the US Bureau of Labor's aggregate Consumer Price Inflation or CPI index. This index is periodically re-calibrated to a given year, in which the CPI is reset to a value of 100. As of

2016 the CPI is set to 1982-1984 as 100. This means that the CPI value at the end of 2016 was 236. In carrying out inflation adjustments it can be confusing to adjust a 2015 value to a 1982-84 value. For example, a price of $1,000/AF at the end of 2015 would be $2,360 in 1982-84 constant dollars. But since we are in 2016 it would be strange to think about prices in1982-84 dollars. So it is common practice to simply adjust the index value to a recent year and reset this year to an index value of 100. For example, if we did this then a $2,360/AF water transaction back in 1983 would be expressed in constant 2015 dollars as costing $1,000/AF. In Appendix 1 we include a time series of the 1982-84 CPI and the index transformed to produce an index with reference to 2015 constant dollars. This index is then used in deriving inflation adjusted cost-effectiveness figures in the application provided in Section 8.

6.5.2 ADJUSTING FOR THE TIME VALUE OF MONEY: DISCOUNT RATES

Once monetary figures are adjusted for inflation we are still left with a problem of commensurability within and between transactions when the costs or benefits of transactions occur in different periods. Cost-effectiveness analysis is a variant of cost-benefit analysis. This type of analysis has a long history as a tool for analyzing both private and public investments. These analyses provide a way to assess if a capital investment is "worth it" as well as a consistent approach for comparing alternative investments, that may have different project lives. Capital investments are characterized by significant up-front expenditures, which then generate benefits over many periods into the future. The question is how to add up these benefits that occur over the long term and compare them with the costs, which are incurred predominantly in the near term? With regard to these investments there are two reasons why economists and financiers employ discount rates to take future streams of project benefits and bring them back to a present value that can be compared with the costs of the investment.

The opportunity cost of capital refers to the foregone benefits when financial capital is allocated to the project under analysis. Capital may be invested in a range of activities (development projects, the capital markets, etc.) each with its own risk and rate of return. The central point is that when investing public funds in, say, EWTs these funds could have been used in other investments and those investments would have made a return on that capital. In other words the use of the capital in the EWT is not "free." It comes with an opportunity cost. In the simplest case the funds could be put in the bank and earn interest.

The social rate of time preference looks at the question of how to value costs and benefits over time from the perspective of how society values consumption. There is a generalized preference for consumption now as opposed to the future. Given a choice, and other things equal, people prefer to consume food, clean water, electric power, back-country skiing, etc. sooner rather than later. There are many explanations for this, but the simplest is the risk of our continued existence. As there is some probability that we will not be around tomorrow we have a preference to consume things today.

These two concepts, the opportunity cost of capital and the social rate of time preference, can be combined into the simpler phrase "the time value of money." If you win the lottery would you prefer to receive an inflation-adjusted amount of $100,000 a year for ten years or $1 million today? Most would choose the former because (a) you would probably want to buy things now and you might be dead in ten years and (b) you know you can invest the money and effectively have more money to spend.

In practice, the time value of money is deployed via a discount rate, which is simply the inverse of an interest rate. It is not the rate at which an investment grows through compounding, but the amount at which a future benefit (or cost) is discounted back to a present value. The discount rate for costs occurring immediately is 0, these figures are already in their present value. The discount rate for future streams of costs and benefits can be expressed in real or nominal terms. Cost-benefit analysis is typically undertaken in real (inflation-adjusted) terms. Real discount rates typically used in project evaluation in the US and overseas typically are from as low as 2% up to 12%. Higher discount rates are often deployed in fast growing economies reflecting the scarcity of capital and the many highly productive uses of that capital in these economies.

Some environmental advocates and some economists argue for using a very low or zero discount rate when it comes to the evaluation of long-term environmental change, such as that accompanying climate change (Cline 1999; Cline 1992). Using a zero discount rate effectively says that a unit of water today has the same economic value as a unit of water in 100 or 1,000 years. The argument for lower discount rate often stems from a reliance on a low (or zero) social rate of time preference.

Unfortunately, this argument cuts both ways. A low discount rate also favors the approval of long-lasting infrastructure, which can itself cause large environmental changes. For example, the expansion of large dams and flood control projects was supported by the use of low discount rates by federal agencies back in the mid-1900s. As with most debates over economic values for environmental goods and services this debate is not easily resolved. The approach taken here is to recommend that in preparing a cost-effectiveness analysis (or a cost-benefit analysis) it is best to stick with traditional economic approaches and push concerns about the use of economic valuation and discounting with water and the environment into broader decision-making venues or other broader technical approaches (such as multi-criteria analysis). Concerns about discounting streamflow for fish associated with permanent transactions may be best integrated into decision-making not by altering discount rates but by specifying the duration of transactions as separate criteria from the cost-effectiveness of the transaction. In this way, this information make it all the way through to the final multi-criteria analysis.

For the US as a mature economy the real discount rate is likely to be on the lower end of this range. In 1992 the US Office and Management and Budget in its circular A-94 on Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs recommended a 7% real discount rate for base case analysis of public investment decisions. This reflects the before-tax rate of return to private capital in the US economy, and still did in 2003 according to OMB Circular A-4. Circular A-4 pertains to regulatory analysis and calls for using the 7% amount as the high end for real discount rates, but 3% as the low end. For cost-effectiveness analysis of federal investments, Circular A-94 calls for using the real interest rates on treasury notes and bonds, matched to the maturity of the instrument. OMB updates these figures each year in Appendix C of the circular. For 2016 the thirty-year figure is 1.5%. This represents practically an all-time low with the annual figures ranging from 1.1% in 2013 to 7.9% in 1982. A particular problem with using these Appendix C values is that the investments that will be analyzed will have been made in previous periods making this approach a moving target in terms of which discount rate will be used. Further, as a general statement the funds for use in water transactions programs come from a variety of federal, state and private sources. Therefore, 1.5% to 8% discount rates represent the range of rates as reviewed here. For the purpose of a central estimate we use 5% or the midpoint between the regulatory figures of 3% and 7%.

A positive discount rate of 5% is recommended for comparing wet water amounts in cost-effectiveness calculations.

6.5.3 COMPARING TRANSACTIONS WITH DIFFERENT BENEFIT PROFILES

A final consideration in the use of cost-effectiveness analysis relates to the likelihood that water transactions will have a variety of cost and benefit profiles. For example compare three types of transactions:

1. A one-year lease of 10 AF for $100/AF and a total cost of $1,000.
2. A ten-year transfer of 10 AF/yr for $100/AF/yr (inflation-adjusted) with a total up-front payment of $10,000.
3. A transfer of 10 AF/yr in perpetuity for $4,000/AF with a total investment of $40,000.

In this case the benefits are the same, but vary in duration, and the costs vary. So, which is the most cost-effective transaction? The costs are all occurring in the same and first year so they are not discounted. The benefits however cover different time frames. If we just divide the total costs by the total volume of water acquired we arrive at the following for the first two transactions:

1. $100/AF.
2. $100/AF.

But how do we express the water volume acquired by a transaction that will provide flow in perpetuity? For the sake of argument let's use 20, 100 and 1,000 years. This generates cost-effectiveness figures of $200/AF, $40/AF and $4/AF. Which is the correct figure? If the correct time frame is 20 years this is the most expensive transaction. If it is 100 or 1,000 years this is by far the least cost transaction. Clearly this constitutes a problem.

There are two ways to resolve the issue. The first is called life cycle cost analysis. The analysis compares all three transactions over a similar time frame. For example we might choose 50 years as a reasonable time frame and compare the following:

1. The one-year lease repeated each year for fifty years.
2. The ten-year transfer repeated five times.
3. The permanent transfer with 50 years of benefit.

This approach attempts to exactly replicate the non-monetary benefits. The discounted costs of each option can then be compared to assess cost-effectiveness.

This approach can be cumbersome when a large variety of different transactions or projects are to be compared, all with varying amounts of water benefits over time, and potentially varying costs over time. A more flexible method is simply to discount the water benefits. For example for programs with identical costs but differing benefits, Circular A-94 recommends using the discounted present value of benefits as the decision criterion. Returning to the first example above the analysis would look like the following for each of the three transactions:

1. For the one-year lease the cost and water benefit to occur in the first year so the cost-effectiveness metric is $100/AF, with the acre-feet in present value terms.
2. The ten-years of 10 AF are discounted over ten years at 5% resulting in a figure of 81 AF acquired for the $10,000 or $130/AF.
3. Over 100 years the total discounted duty is 208 AF for a cost-effectiveness of $202/AF.

In this case the lease is the most cost-effective option.

*"Options and Obstacles: Living with Low Water Flows in the Mattole Headwaters." Sanctuary Forest, 2004

7. PRACTITIONER SURVEY ON COST AND EFFECTIVENESS MEASURES

The goal of this survey was to better understand how organizations engaged in water transactions collect and use cost and effectiveness data about water transactions. We used an iterative development process to design the survey in order to frame questions and responses in such a way so as to most effectively capture information.

Survey categories were focused on gathering information related to:

- demographics and work;
- environmental water transactions;
- water costs and transaction costs;
- tracking costs;
- measuring the flow and ecological benefits of water transactions;
- funding; and
- cost effectiveness.

After survey questions were finalized, an online survey was created using Google Forms. Requests for survey participation were sent initially via email to individuals and organizations in California known to be interested in or to participate in water transactions. The method used to identify and solicit survey participation was not one conducive to estimating a response rate for the survey, so one is not presented here. Suffice it to say that of roughly twenty emails five responses to the survey were received. This number approximated our expectations with regard to the number of practitioners with an active history of implementing environmental water transactions in California.

Subsequently, the email request to fill out a non-California version of the survey was emailed out to entities and individuals known to be engaged in environmental water transactions across the western US and northern Mexico. From a pool of approximately 60 emails, many of which went to multiple staff in a single organizational office, a total of 23 responses were obtained within a two to three week period.

One concern about the solicitation method chosen was the potential for disproportionate representation from one or more organizations to skew the results. While not a required question, we did ask respondents to include the name of the organization for which they worked in order to account for multiple responses from a single organization in the results. This concern was more an issue in the California survey as reviewed below. Both surveys are reported on separately so that any differences between the two samples can be noted, but also because these surveys were conducted sequentially.

7.1 CALIFORNIA SURVEY RESULTS

Of the five individuals responding to the California component of the survey, two individuals each represented two organizations and the last individual was self employed. With this caveat, results presented include all individual's responses and are not weighted based on number of responses from a single organization.

With regards to funding, all five respondents stated national foundations provide funding directly to their organization to complete water transactions. Only three of the five stated their organization receives funding for water transactions from the state of California.

Of the various water transactions types, results showed that respondents' organizations generally were less likely to engage in long-term transfers and land purchases and more likely to engage in water user agreements (e.g., forbearance, diversion reduction, minimum flow agreements) and split season transactions.

Of the four respondents who answered the question, all used a spreadsheet format to input and store data on water transactions. In addition to the spreadsheet format, some also used documents, organizational databases and funder databases.

With respect to costs over time, only one respondent stated their organization "regularly" reports and compares expenditures on water costs and/or water transactions across years. The other three respondents to this question stated it was done "occasionally, as the need arises".

When asked if their organization adjusts values for inflation when comparing multiple years of water and/or transaction costs three of four respondents answered "no" and the fourth was not sure.

Of the response choices to a question about the terms typically used measure and evaluate the flow benefits of transactions, the only metric not used by any of the respondents' organizations was "volume of water right dedicated to environmental use (i.e., acre-feet)". All other metrics listed as response options were used by all respondents, with the exception of "the reliability of the water right (i.e., seniority/priority date)" which was used by four of the five.

Organizations of all respondents used some method to predict how much water those transactions are expect to yield in the future (when not fully senior), although the responses were distributed with "models of water rights and water supply to calculate likely water yield" being the most popular method used.

All respondents stated their organization used some method to measure the amount of flow its water transactions actually provide—two stated their organizations directly monitors streamflow improvements, two stated their organization relies on other entities to do the monitoring and the fifth selected "other" with a follow-up that a combination of monitoring was used.

Of the response choices for the types of ecological benefits of transactions measured by respondents' organizations, the two options not monitored by any organization responding were "aquatic species survival" and "aquatic species population". Of those measured, the type(s) varied by respondent: three measure habitat, three measure water quality, two measure fish passage and one measures flow. The most metrics any one organization measures is three.

With regards to calculating cost effectiveness, two and one respondents stated their organization typically calculated volume ($/acre-foot) and flow ($/cfs) increase metric, respectively. None of the other metrics listed as response options are typically calculated (e.g., $/cfs, $/river mile, $/acre, $/increment of ecological benefit).

For their "water program as a whole," one respondent each stated that their organization tracked $/acre, $/cfs and $/increment of ecological benefit, respectively. Other responses options, such as $/acre-foot, $/river mile and $/cfs increase metric, typically are not tracked by any of the respondents' organizations.

Of the four individuals responding to the question, all stated their organizations calculate aggregate costs data about transactions and cost per unit statistics at least sometimes, with two stating it is done yearly within their organization.

7.2 OTHER (NON-CALIFORNIA) SURVEY RESULTS

Email requests and the survey link were also sent to staff of organizations known to be engaging in environmental water transactions outside of California. Twenty-three individuals from thirteen organizations responded to the survey by the survey due date. National non-profits accounted for just over half of the organizations represented, while another one-quarter of respondents work for local non-profits (see Table 3).

Table 3. Summary of Organization Type

Organization type	% of responses
National non-profit	52.2%
Local	26.1%
State non-profit or state chapter	8.7%
State government	8.7%
Other	4.3%
Federal government	0.0%

Results show that respondents work within the legal jurisdiction of ten states (i.e., AZ, CO, ID, MT, NM, NV, OR, UT, WA, WY) and one area of Mexico (i.e., Baja California and Sonora). It is interesting to note that only one respondent listed more than one state to describe the legal jurisdiction in which they work. That particular individual stated he/she works in five different states (i.e., AZ, CO, NM, UT, WY).

Respondents were asked to describe the scale(s) at which they work. A sub-basin was the response most frequently selected (65.2%), while "an entire basin" received the lowest number of responses (17.4%) (see Table 4).

Table 4. Summary of Scale(s) at which Respondents work

Scale of work	% of responses
An entire sub-basin	65.2%
Headwater creeks & streams	56.5%
Mid- or lower-basin streams & rivers	56.5%
State	21.7%
An entire basin	17.4%
Other	0.0%

Almost all respondents (95.7%) stated they receive funding for water transactions from national foundations, while approximately three-quarters receive funding from state and/or federal funding sources. Respondents were least likely to receive funding from a corporate donor (see Table 5).

Table 5. Funding Sources

Funding sources	% of responses
National foundation	95.7%
State government	78.3%
Federal government	73.9%
Private donor	47.8%
Regional/local foundation	43.5%
Corporate donor	34.8%
Other	8.7%

With respect to the types of transactions, respondents' organizations are most likely to be regularly engaged in water leases (69.6%), water right purchases and transfers (47.8%) and conserved water (47.8%). Respondents are least likely to engage regularly in whole farm/ranch purchase transactions (4.5%) and most likely to never engage in this transaction type ever (68.2%) (see Table 6).

Table 6. Frequency of Engagement by Transaction Type

Transaction type	Never	Very rarely	From time to time	Regularly
Water right leases	17.4%	8.7%	4.3%	69.6%
Water right purchase & transfer	21.7%	13.0%	17.4%	47.8%
Conserve water	17.4%	13.0%	21.7%	47.8%
Long-term water right leases	22.7%	18.2%	13.6%	45.5%
Water user agreements	13.6%	22.7%	27.3%	36.4%
Split season transactions	13.6%	22.7%	31.8%	31.8%
Whole farm/ranch purchase	68.2%	27.3%	0.0%	4.5%

We next asked respondents to estimate the proportion of their organizations' water transactions that are split-season (versus full-season) and temporary (versus permanent). As seen in Table 7, just over half of respondents stated their organization does "some" split-season transactions. Only one respondent (4.3% of total) stated that all of their organization's transactions are split-season. With respect to temporary versus permanent transactions, two respondents (8.7%) answered that their organizations do not do any temporary transactions, while another three stated that temporary transactions were the only type in which they did engage. The majority of respondents answered that "some" or "many" of their transactions are temporary, suggesting these organizations do a mix of both temporary and permanent transactions.

Table 7. Frequency of Temporary and Split Season Transactions

Proportion	Split season	Temporary
All	4.3%	13.0%
Many	13.0%	47.8%
Some	56.5%	30.4%
None	26.1%	8.7%

In terms of storing data related to water transactions, respondents are most likely to use a spreadsheet (69.6%), followed by an organizational database (47.8%). Two individuals (8.7%) stated they do not enter data into any of the options listed, nor did they provide an "other" response. Note that respondents could select as many formats as were relevant.

Table 8. Types of Data Storage

Data storage	% of responses
Spreadsheet	69.6%
Organizational database	52.2%
Funder database	47.8%
Document	43.5%
We do not enter data into any of the above	8.7%
Other	0.0%

With respect to tracking the amounts paid to landowners or water right holders as part of a water rights or land/water transaction, respondents are more likely to enter costs into a file (60.9%) compared to other tracking options included in the survey (see Table 9). Again, respondents could select multiple formats.

Table 9. Tracking Methods

Water Costs	Never	Sometimes	Always
Enter costs into file or database	17.4%	21.7%	60.9%
Send annual report to funders, etc.	26.1%	26.1%	47.8%
Generate summary table of all transactions	8.7%	47.8%	43.5%
Present internal annual report	30.4%	43.5%	26.1%

Only three respondents (13%) track both transaction costs for each transaction and separate these costs from other organizational costs at regular intervals, while six respondents (26.1%) never estimate or calculate transaction costs associated with water transactions (see Table 10).

Table 10. Tracking Methods for Transaction Costs

	% of responses
We do not estimate or calculate transaction costs	26.1%
Separate water transaction costs from other organizational costs regularly	21.7%
Calculate transactions costs only when a funder requires it	21.7%
Record/track costs for each transaction as it happens	17.4%
Record/track costs for each transaction as it happens & Separate water transaction costs from other organizational costs regularly	13.0%

Approximately one-quarter of respondents (6 individuals or 26.1%) answered that their organizations regularly report and compare expenditures on water costs/transactions across time. It is interesting to note, however, that only one of these six respondents answered that their organization adjusts for inflation when making these comparisons. Another 56.5% (13 individuals) make such comparisons on an occasional basis, with three of these thirteen respondents stating their organizations account for inflation in their comparisons. The remaining 17.3% stated they never report and compare expenditures on water costs/transactions across years.

With respect to evaluating the water benefit of transactions, respondents were most likely to use flow rate and volume of water as tracking metrics (see Table 11).

Table 11. Metrics for Evaluating Water Benefits of Transactions

Metric	% of responses
Flow rate	90.0%
Volume of water	86.4%
Miles of stream receiving additional water	77.3%
Time period transaction is in effect	77.3%
Reliability of water right	68.2%
% of streamflow target reached	50.0%
% change in flow rate	40.9%
Other	22.7%

The majority of respondents (81.8%) answered that their organizations consider seniority of rights when conducting transaction, but work with all priorities. The other 18.2% only conduct transactions with senior water right holders. A variety of methods are used by organizations to predict how much water transactions are expected to yield in the future (see Table 12), with some organizations using multiple methods. The most popular method is using historic watermaster records of when water rights are in priority to estimate future water yield (70%).

Table 12. Methods of Estimate Future Water Yield

Method	% of responses
Historic watermaster records	70.0%
Models of water rights & water supply	60.0%
Rule of thumb figures provided by informed sources	55.0%
We do not estimate	20.0%
Other	15.0%
Complex water distribution model	5.0%

The majority of respondents' organizations (86.4%) typically measure the amount of flow their water transactions actually provide, with approximately half conducting the monitoring themselves and half relying on monitoring done by other entities. The remaining 13.6% answered that their organizations do not monitor streamflow associated with their transactions.

Habitat (50%) and water temperature (50%) are the ecological benefits most likely to be tracked (see Table 13). Of the four respondents that selected only one ecological benefit as being measured by their organization, two track habitat and two track water temperature. Six individuals (26%) did not list any ecological benefits as being currently measured by their organization.

Table 13. Measurement of Ecological Benefit

Benefit	% of responses
Habitat	50.0%
Water temperature	50.0%
Fish passage	44.4%
Other	27.8%
Water quality	22.2%
Aquatic species population	22.2%
Aquatic species survival	11.1%

We asked several questions related to metrics used for and frequency of tracking the cost-effectiveness of water transactions. The majority of respondents track $/cfs and $/acre-foot for both individual transactions and their transaction program as a whole (Table14). Individuals who included an "other" response included $/change in applied (pumped) irrigation water and $/reliable acre-foot as the metrics they use.

Table 14. Metrics for tracking cost effectiveness

Metric	each transaction	Whole program
$/acre-foot	85.7%	84.2%
$/cfs	71.4%	68.4%
Other	9.5%	15.8%
$/river mile	4.8%	0.0%
$/change in streamflow	0.0%	5.3%
$/increment in ecological benefit	0.0%	0.0%

With respect to frequency of tracking, just over one-third (39.1%) responded that their organization tracks aggregated costs data on transactions on an annual basis. Another 43.5% and 17.4% answered that their organizations track it occasionally and never, respectively.

Responses were similar for tracking of cost per unit statistics, with 30.4% calculating these annually, 52.2% occasionally and 17.4% never. In comparing the answers across respondents, it is interesting to note that the same individuals selected "never" for both questions, as did individuals selected "sometimes. The only variation seen, therefore, was that some individuals whose organizations track aggregated costs data yearly only do so only occasionally for cost per unit.

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8. APPLICATION OF WATER COST-EFFECTIVENESS METRIC TO WHYCHUS CREEK, OREGON

As part of developing the cost-effectiveness it was intended to attempt an initial application of the approach. The goal was to demonstrate its use and provide an initial testing of the approach. Early in the project it became clear that a number of factors would mean that undertaking this demonstration in California would be difficult. The limited number of environmental water transactions in California, the need to apply the water cost-effectiveness metric in a particular geographic area, the desire to compare different types of transactions over a significant timespan and the need to adjust for the reliability of water rights all suggested it would be better to apply the metric in a site familiar to the authors and one in which many transactions had been overtaken over a period of years. For this reason this initial application of the methods described above is undertaken in Whychus Creek in the Deschutes Basin, Oregon.

8.1 WHYCHUS CREEK STREAMFLOW RESTORATION BACKGROUND AND LEGAL CONTEXT

Prior to their extirpation by the mid-basin Pelton Round Butte hydropower complex in the mid-1900s, Whychus Creek provided a significant portion of Chinook salmon and steelhead spawning habitat in the basin. Since the mid-1990s, the Oregon Water Trust, the Deschutes River Conservancy, the Deschutes Land Trust and the Upper Deschutes Watershed Council have cooperated on efforts to remove entrainments, restore stream channel and floodplain habitat, conserve and restore riparian areas, and restore flows in Whychus Creek in order to rebuild resident fish populations (largely trout) and prepare for the day when anadromous runs are re-established above the dams. The latter effort, begun in 1995 led to the relicensing of the Pelton Round Butte project in 2005, and included funding to restore anadromous runs above the dams. A large portion of the funding went to construction of a fish collection facility in Lake Billy Chinook. The first release of juveniles occurred in 2010, with first returns occurring the next year.

As part of this larger cooperative effort a large number of water transactions have been undertaken in Whychus Creek since the late 1990s. These include the following transactions:

- instream leases of individual senior rights and Three Sisters Irrigation District (TSID) rights;
- purchase and instream transfer of individual senior rights;
- piping of TSID canals for allocations of conserved water;
- surface to groundwater switch with TSID;
- downstream point of diversion switch and conserved water with individual water right holders;
- piping of TSID laterals (with or without conserved water); and
- instream lease and transfer of municipal surface water.

In addition, the City of Sisters has purchased portions of a ranch (the Lazy Z) with senior and junior water rights that borders the City. The City sited its wastewater ponds on the corner of the property and has plans to use its wastewater on the property, freeing up the surface water for instream use.

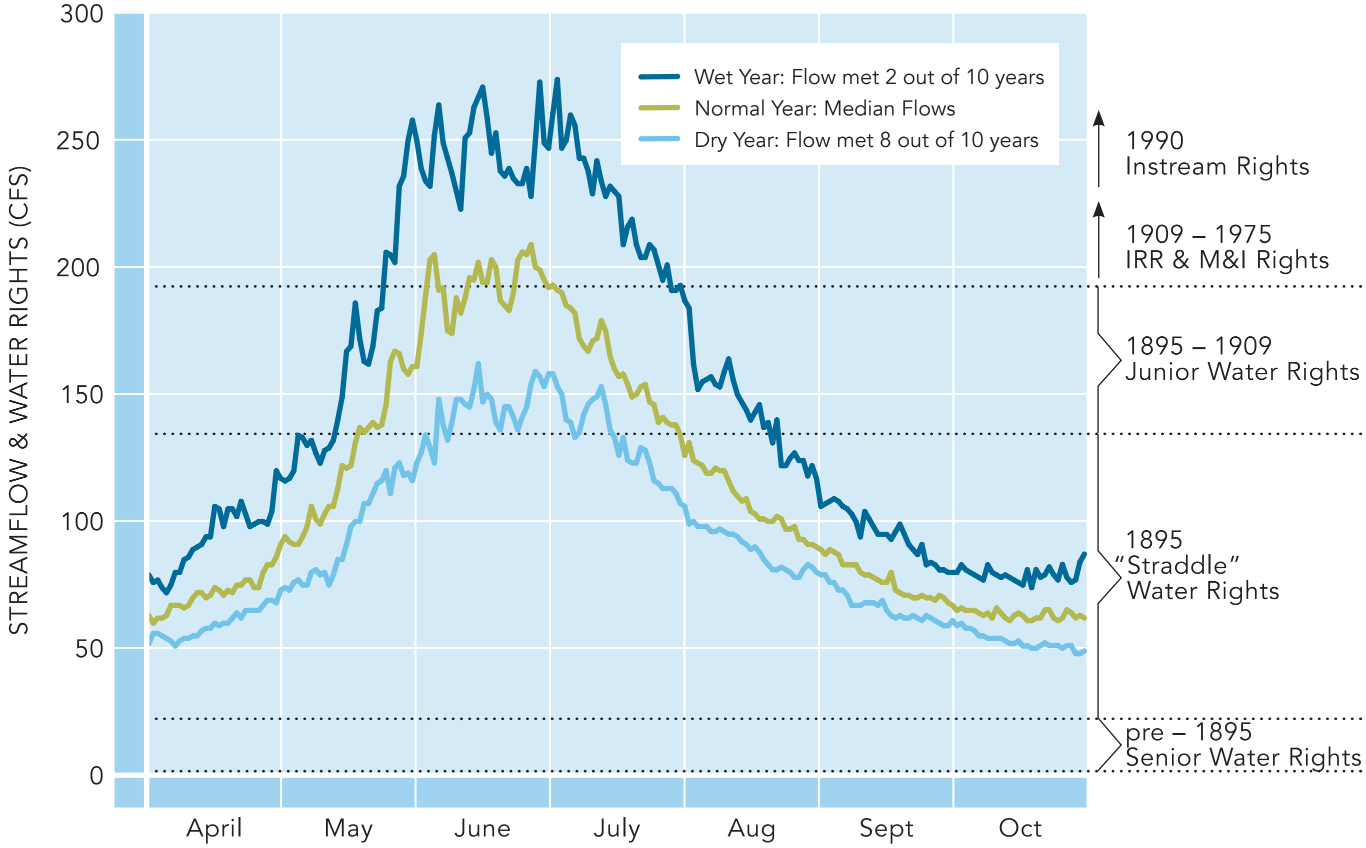
These transactions are carried out in accordance with the following administrative rules (OARs) for the creation of instream water rights, consistent with the Oregon Instream Water Right Act of 1987:

- Division 690-077 Instream Water Rights (transfers and leasing);
- Division 690-018 Allocation of Conserved Water;
- Division 690-505 Deschutes Basin Program (groundwater mitigation); and
- Division 690-521 Mitigation Bank Credit Rules.

8.2 WHYCHUS CREEK HYDROLOGY, WATER RIGHTS AND RELIABILITY

As with any watershed in the west the picture with respect to the validity and reliability of surface water rights in Whychus Creek is complex. Nevertheless, it is essential to understand the water rights and to quantify these demands on the stream and compare them to streamflow (the supply) in order to gage the reliability of different rights for transactional purposes. Figure 3 superimposes a compilation and classification of Whychus water rights over different statistical measures of water availability at the gage on upper Whychus Creek above all diversions. The graphic indicates that under normal flow conditions (median flows), only the most senior water rights (senior to 1895) are available all season long.

Figure 3: Whychus Creek Streamflow (1982-2001) and Water Rights



For the purpose of this report a simple allocation model that assumes no losses on the reach between the City of Sisters and the gage is used to calculate the reliability of the following four classes of water rights:

1. **High Security –** senior rights (pre-1895 priority date).
2. **Medium Security –** the "straddle rights of 1895 priority date.
3. **Low Security –** rights with priority between 1895 and 1903 inclusive.
4. **Very Low Security –** rights with priority of 1904 or junior.

The model takes the monthly median flow over the 1982 to 2011 period and assesses to what degree each class of right can be satisfied. The monthly demand for each class is simulated in the model as either simply the amount of the water right or as the estimated consumptive demand plus losses or the water right amount, whichever is less. The results are shown below for the four classes:

1. **High Security –** 100% reliable under both scenarios.
2. **Medium Security –** 85% reliable under the actual demand at the diversion and 69% reliable under the water right.
3. **Low Security –** 29% reliable under both scenarios.
4. **Very Low Security –** 15% reliable under both scenarios.

Using the water right amount to represent diversion demand has the effect of vastly understating the reliability of the medium security rights in April and October, when actual evaporative crop demand is very low. For this reason, in the cost-effectiveness analysis the 85% reliability figure is used for the medium security class of water rights.

8.3 PROJECT COSTS AND ENVIRONMENTAL WATER

For this application data on all of the permanent instream transfers and conserved water projects carried out through the end of 2015 was collected. These are transactions completed by the Oregon Water Trust and the Deschutes River Conservancy (DRC). As shown in Table 15 these transactions amount to 31.60 cfs of permanent instream flows purchased for almost $17 million. These represent 23 separate transactions (or "projects") and some 40 instream water right certificates.

In Whychus, one- or multi-year instream leases are also carried out each year by the DRC. For this analysis only the three "pooled" leases undertaken in 2009 are included as representative of leasing generally. The DRC has generally not varied payment structure, paying for leased water at $7/AF on either a paper or wet basis since 2002. The total amount of environmental water was 10 cfs but as this occurred in two batches it represents about 5 cfs of instream water throughout the seasons. Approximately, this amount is leased each year by the DRC. These leases involved 17 separate landowners who were paid a total of just over $11,000.

Table 15. Instream Flow Rates for Whychus Transactions by Transaction Type and Water Right

Transaction / Security	Rate (cfs)	Water Cost ($)
Transfers		
High	4.02	537,807
Conserved Water		
High	2.23	
Low	1.09	
Med	22.46	
V. Low	1.80	
Subtotal	27.58	16,374,075
Total (before leases)	31.60	16,911,882
Leases (2009 only)		
High	0.26	
Low	0.75	
Med	8.88	
V. Low	0.85	
Subtotal*	10.73	11,083

Note: *The lease period do not run concurrently, thus the totals overstate the amount of water that is expected to be instream at any one time.

A table of the information necessary to carry out the cost-effectiveness calculations is included in Table 16. A graphic representing the flow of the calculations performed is shown in Figure 4.

Table 16. Cost and Effectiveness Data Requirements

Cost and Effectiveness Data Requirements
1. Transaction data required
a. Information on the financial transaction
i. transaction number - simple unique project tracking number
ii. transaction name (or alias) - again for tracking/identification purpose
iii. type of transaction - e.g., water lease, forbearance agreement, conserved water, etc.
iv. payment date - date buyer paid seller for transaction.
v. amount of payment ($)
b. Information on the environmental/instream water data. This is data on the instream water right or water user agreement. As a single transactional payment may be linked to multiple leases or water right change applications, or may involve multiple priority dates with varying reliability, these entries may need to be itemized by water right and/or priority date.
i. transaction number – the transaction to which this ISW belongs (as per above)
ii. source name (i.e., creek, river, etc)
iii. reach (if not just protected in the entirety of the source)
iv. season of use start date
v. season of use end date
vi. flow rate (cfs)
vii. term (years for which water is put to environmental/instream use, use 100 for permanent transactions)
viii. effective date (i.e., if a water right change is involved the date on which it was approved and available for environmental/instream use)
ix. water right reliability (in % during the season of use)
2. General economic parameters required
a. CPI inflation indices
b. discount rate

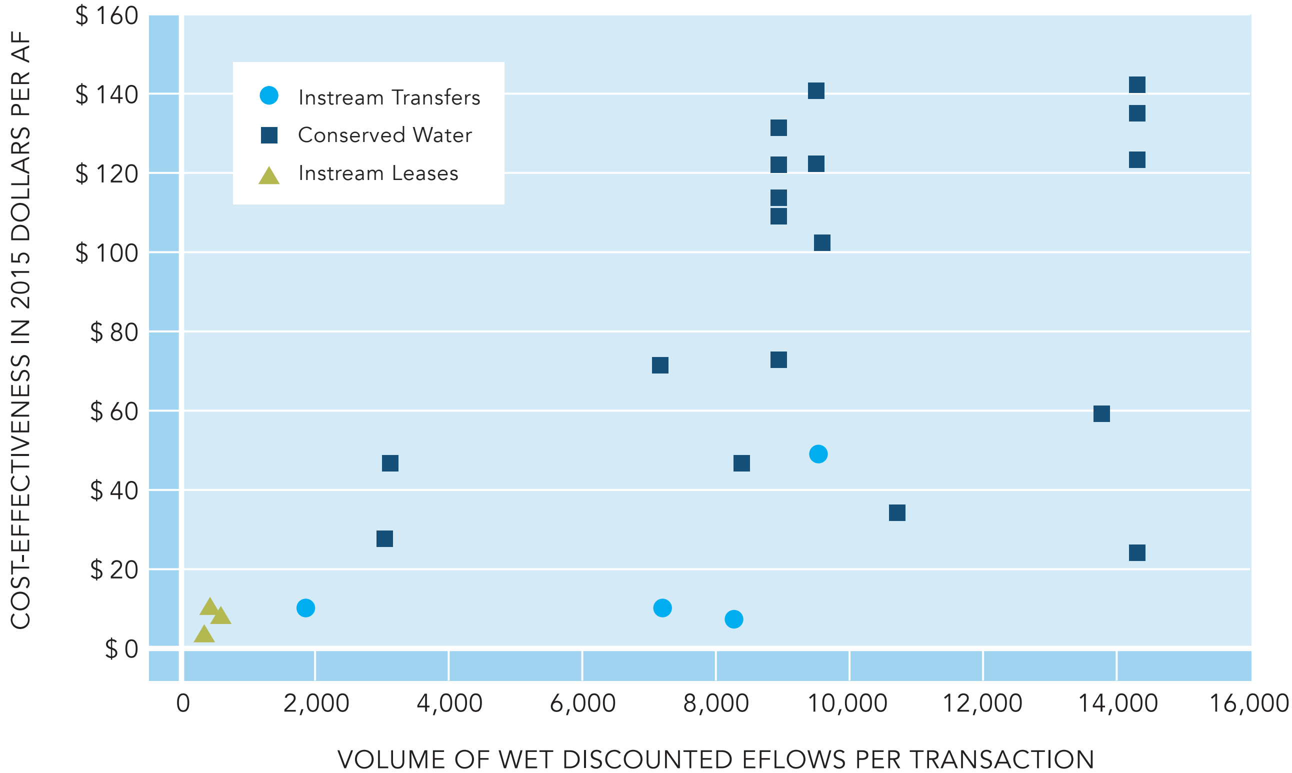
Figure 4: The Cost-Effectiveness Calculation Procedure

COST-EFFECTIVENESS (CE)	
$$CE = \frac{\textit{Inflation Adjusted Cost (\$)}}{\textit{Wet Discounted EFlows (AF)}}$$	
Transaction Water	Water Costs
↓	↓
Adjust to EFlows	Transaction Costs
↓	↓
Adjust to Wet Water	Total Costs
↓	↓
Discount Water	Adjust for inflation
↓	↓
Total Wet Discounted EFlows	Inflation Adjusted Cost

8.4 RESULTS

The results for each transaction type are presented in Figure 5. Leasing tends to be low cost and low volume. This reflects the annual nature of instream leasing. As indicated above the DRC leases approximately the same amount of water each year at the same price and thus over time it could be said that leasing is a program that would generate larger volumes over time. In other words the green triangles representing the 2009 leasing year could be portrayed much further to the right, i.e., increasing the volume of environmental water that they generate, but at the same low cost, i.e., well below that of the higher cost transfer.

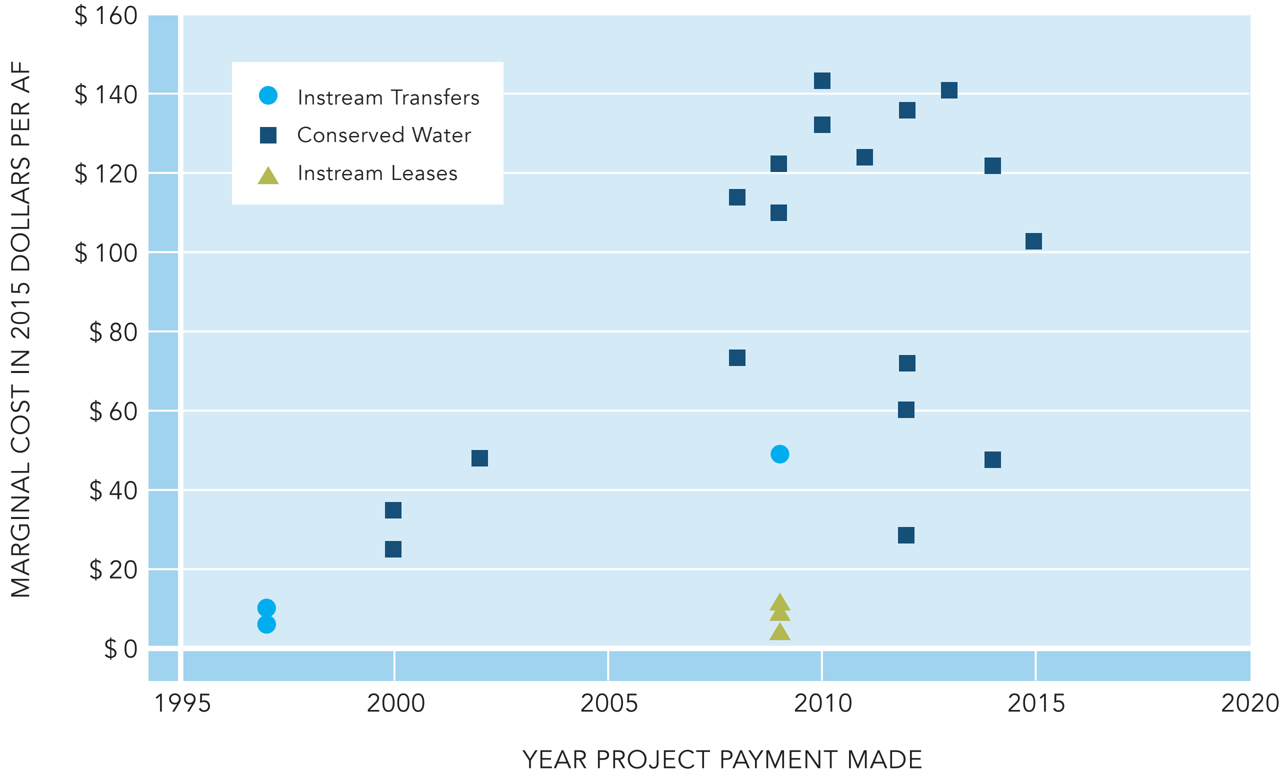
Figure 5: Cost-Effectiveness of Whychus Transactions



The three lower cost transfers represent a significant amount of water, 1.81 cfs annually throughout the irrigation season, and are of relatively low cost. These were the "low hanging fruit" first transacted in the late 1990s by the Oregon Water Trust. As such these were obtained at a very low price at the time. The subsequent transfer, completed many years later, came in at a cost approximating that of the less costly conserved water projects. Additional transfers are underway of these senior, non-TSID water rights.

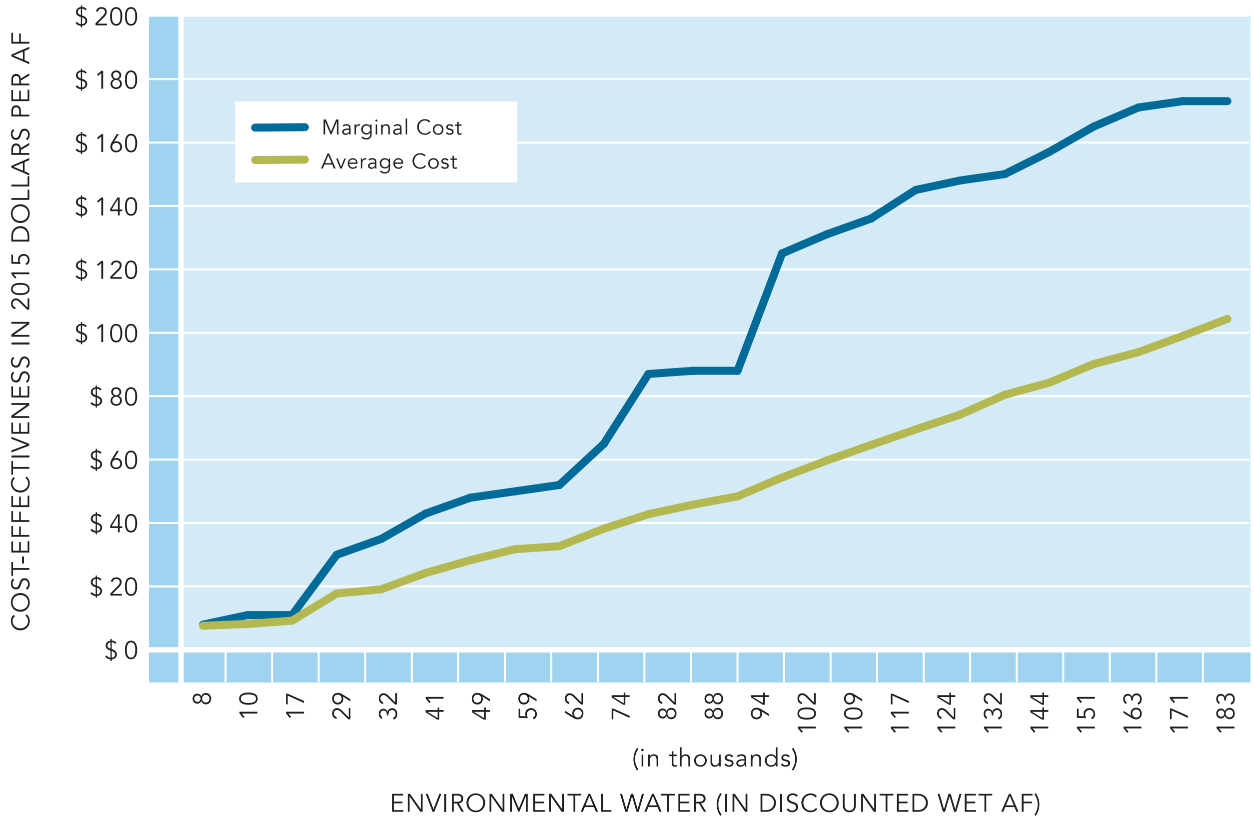
Conserved water displays the greatest variation in cost-effectiveness, varying by a factor of up to four from low to high cost transactions. Further definition to the cost of these projects can be discerned from Figure 6. In this figure the cost-effectiveness is plotted over time. A clear upward trend can be seen in the transfers and the conserved water. For conserved water the three low cost projects in recent years are anomalies, two being projects involving the piping of laterals (whereas most conserved water is from main canal projects) and one is a point of diversion change and conserved water for an individual water right. Absent these project the strong trend to increasing cost in the conserved water obtained from TSID canal piping projects can clearly be seen.

Figure 6: Cost-Effectiveness of Whychus Transactions over Time



Finally, once these cost-effectiveness calculations are undertaken it is also possible to construct marginal and average cost curves for flow restoration in Whychus Creek. In this case this is done using just the permanent projects (see Figure 7). For flow restoration to date the average cost in 2015 dollars of an acre-foot of environmental water is $100/AF. The marginal cost to achieve over 182,000 discounted wet acre-feet of flow restoration is almost $180/AF. Note that the slope of the average cost curve provides an indication of the additional costs of achieving different flow levels or targets in the creek. Also note that the shape of this curve is unique to the particular conditions in Whychus Creek. Nevertheless it would be interesting to see what form and shape such curves take in other locations.

Figure 7: Cost-Effectiveness of Whychus Permanent Transactions: Marginal and Average Costs



It is difficult to accurately portray the meaning of these results absent a more detailed review and understanding of the context in which these transactions occur. Before attempting this it is important to emphasis three things:

1. The environmental water and cost-effectiveness metrics are in dollar and acre-feet terms but as highly processed figures they cannot be loosely compared to simple dollar or acre-feet terms but only to other 2015 dollar per discounted wet acre-feet and discounted wet acre-feet terms.

2. The limitation of the water cost-effectiveness metric is that it does not convey much about the effectiveness of the expenditure in reaching a particular flow or ecological target, or anything about how important reaching those targets might be.

3. Comparison of these cost-effectiveness figures with those from other watersheds or basins is therefore not recommended, without understanding the full context in each locale.

Nevertheless, as all three types of transactions produce acre-feet of water in the same reach towards the same target and the same ecological objective the cost-effectiveness figures are useful in assessing the cost of flow restoration and comparing different transactional strategies to attain flow and ecological objectives. In addition, as an initial step in this direction observations about the behavior of these costs across transactions and across time are of interest, as would be comparison to such behavior in other locations.

With these caveats in mind, a simple reading of the results suggest the following findings about environmental water transactions in Whychus Creek:

- Conserved water is the least cost-effective transaction but also the most widely deployed approach, and has increased dramatically in (inflation-adjusted) cost over time;
- Transfers have also increased in cost over time and appear to be of intermediate cost compared to conserved water and leasing; and

Leasing is a time-limited and relatively small impact approach, but is a very low cost method of obtaining instream flows.

Further exploration of these findings would require a full description and analysis of the Whychus context, which is beyond the scope of this report.

9. CONCLUSIONS AND RECOMMENDATIONS

The report had the objective of investigating the topic of cost-effectiveness of environmental water transactions and providing recommendations on what such a cost-effectiveness measure should be and how it should be calculated. A final objective was to test the applicability of the methods with an initial application to real world data.

The report began with an explanation of the potential types of environmental water transactions in the California context, including their relative advantages and disadvantages. This discussion was based on general experience with such transactions across the western US, extending these to the suite of transaction tools available under the California water code. The results suggest that there are a number of tools available to practitioners in California. Although there are remaining issues that could be improved upon through legislation or clarified administratively, there is a growing experience with these tools on the part of practitioners. New funding under the 2014 California water bond should help to focus attention on further experimentation and upscaling of environmental water transactions.

The purpose and use of cost-effectiveness information is then discussed focusing on how each of the various groups involved in these transactions is likely to view the issue. Separate discussions enable a review of cost and effectiveness metrics before an effort is made to identify useful cost-effectiveness metrics for environmental water transactions and outline relevant methods.

The conclusion of this discussion is that there are a variety of reasons why a particular group might want cost-effectiveness information. It is probably most useful to start with the practitioner and work outward from there. In this regard cost-effectiveness analysis is potentially a very useful tool for guiding on the ground planning and implementation of flow restoration programs. As such cost-effectiveness metrics need to be practical and replicable, and must be able to be applied in the planning stages (i.e., before undertaking the transaction) and must be able to be applied on a transaction-by-transaction basis across a range of transactions. For this reason the report puts forward a volumetric cost-effectiveness metric, in other words a dollars per acre-foot metric. However, the actual calculations must account for inflation, different term lengths for transactions and differing reliability between individual transactions. Thus, even this basic cost-effectiveness metric is involved, and a considerable amount of the report is spent developing the methods, examining whether practitioners currently collect or use such information, and carrying out an initial application of the approach to prove its workability.

Beyond the narrow confines of practitioners and their leadership or funders who all wish to ensure that the least cost approach is being taking to flow restoration in a given reach or system, are the larger questions of how to allocate public funds across distinct areas. In these cases the basic volumetric cost-effectiveness indicators offers some information, but does not really convey the complexity of the effectiveness of various transactions in terms of their increment toward flow targets or towards habitat or ecological goals. In order to compare across distinct geographies more advanced metrics are required. These metrics will be difficult to apply on a transaction-by-transaction basis, but may be able to be applied on a regional basis or even on a programmatic basis. We do point out that even with such advanced metrics in hand the problem of commensurability may still exist. How do you compare an ecological restoration outcome in one system with that in another? Is meeting a flow target in a 5 cfs stream at all comparable to that in a 500 cfs river? How do you compare restoration of an extirpated population of Chinook salmon in one basin with the restoration of a population of Coho salmon in another basin?

The conclusion of this report is that it is better to walk first and run later. Basic cost-effectiveness information as laid out in this report is not yet being prepared by most entities engaged in this field, nor do large public funding programs require the information to be provided. Therefore, the first step is to adopt and adapt the volumetric cost-effectiveness approach to the needs of the various entities engaged in environmental water transactions. Provision of the basic data necessary to carry out the cost-effectiveness calculations laid out in the report is a straightforward matter. If practitioners do not have the requisite information, then it may assist them in their efforts to conduct strategic and cost-effective flow restoration programs to begin to collect and apply this information. Further efforts to apply these metrics in particular sites should help the robustness of the approaches described in this report and provide further insight into best practice. Of particular value would be for public funders that run targeted funding programs and larger challenge grant programs, such as the California Wildlife Conservation Board and Bonneville Power Administration's Columbia Basin Water Transaction Program to adopt a common set of standard data requirements for their grantees and to regularly produce cost-effectiveness data from funding applications received.

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On Front Cover:

Chinook salmon, Lower Tuolumne River. Photo: Dan Cox, USFWS
Diversion of natural river flow has contributed to decreases in salmon spawning habitat, both in quality and quantity.

Measuring Flow in Stanshaw Creek. Photo: Konrad Fisher
Baseline and ongoing flow measurements are required to determine the flow benefit of EWTs.

Dewatered Scott River. Photo: Scott Harding / Klamath Riverkeeper
It is crucial that EWTs result in greater in-stream flows.

Fly fishing on the American River. Photo: Lisa Oulette
Reduced flows in our rivers and streams threaten the multi-million-dollar river recreation and tourism industry.

On Back Cover:

Klamath Basin wetland, Scott Harding / Klamath Riverkeeper
Investing in improved stream flows gives our watershed ecosystems the chance to flourish.

Appendix 1. CPI Figures

ANNUAL CPI		
YEAR	1982 – 1984 = 100	2014 = 100
1982	97	246
1983	100	238
1984	104	228
1985	108	220
1986	110	216
1987	114	209
1988	118	200
1989	124	191
1990	131	181
1991	136	174
1992	140	169
1993	145	164
1994	148	160
1995	152	156
1996	157	151
1997	161	148
1998	163	145
1999	167	142
2000	172	138
2001	177	134
2002	180	132
2003	184	129
2004	189	125
2005	195	121
2006	202	118
2007	207	114
2008	215	110
2009	215	110
2010	218	109
2011	225	105
2012	230	103
2013	233	102
2014	237	100
2015	237	100

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