

Yakima River Basin Study

Market-Based Reallocation of Water Resources Technical Memorandum

U.S. Bureau of Reclamation
Contract No. 08CA10677A ID/IQ, Task 4.12

Prepared by

ECONorthwest



U.S. Department of the Interior
Bureau of Reclamation
Pacific Northwest Region
Columbia-Cascades Area Office



State of Washington
Department of Ecology
Office of Columbia River

March 2011

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1.0 Introduction

This memorandum presents the economic assessment of the Market-Based Reallocation of Water Resources element of the Yakima Basin Integrated Water Resources Management Plan (Integrated Plan). The objective of this memorandum is to estimate the extent to which the plan might stimulate market-based reallocation of water to offset irrigation-related economic losses within the Yakima Project due to future, severe drought conditions.

The memorandum first describes the anticipated economic losses and the extent to which market-based reallocation of water potentially would offset the losses under the no action, or baseline, scenario that does not include implementation of the Integrated Plan. Then it describes the potential for additional offsets to the economic losses from implementing the market-based element of the Integrated Plan. The memorandum considers the potential effects of the market-based element both in isolation and as a complement to other components of the Integrated Plan.

The analytical approach has the following major components:

- Compare annual net farm earnings of irrigators within the Yakima Project with and without the market-based reallocation element of the Integrated Plan.
- Develop a spreadsheet model of irrigation that simulates trades that would move water from crops with lower annual net farm earnings to crops with higher annual net farm earnings per acre-foot.
- Apply current data on crops, crop-irrigation requirements, crop prices, and variable crop-production costs. Apply consistent data, assumptions, and calculations across different scenarios.
- Estimate the potential impacts on annual net farm earnings for a core scenario that has the following characteristics and assumptions:
 - Future severe droughts would provide 40 percent of full entitlement for proratable irrigators.
 - Focus on five entities in the Yakima Project: Roza Irrigation District (Roza), Kittitas Reclamation District (Kittitas), Sunnyside Valley Irrigation District (Sunnyside), Wapato Division (Wapato), and Yakima-Tieton Irrigation District (Tieton)¹.

To facilitate the presentation, the following discussion refers to each of these entities as a district.)

- All irrigators in these districts would be willing to sell or buy water when the available water supply falls below crop-irrigation requirements.
- Irrigators experiencing reduced supplies would use water to satisfy the crop-irrigation requirements of their higher-valued crops as much as possible, leave other acreage unirrigated, and realize no net farm earnings from the fallowed land.
- Tieton and Wapato Districts would experience only intra-district trading when available water supply falls below crop-irrigation requirements; Kittitas, Roza, and Sunnyside Districts would experience intra- and inter-district trading.
- Buyers would lease water only for crops with annual net farm earnings of at least \$150 per acre-foot.

¹ The analysis does not include Kennewick Irrigation District because it typically does not experience reduced water availability during a severe drought that affects other districts.

- No more than 10 percent of the annual water supply during a severe drought for Roza, Kittitas, and Sunnyside Districts would be sold out of the district.

Alternative scenarios will impact the last two assumptions by considering (a) buyers leasing water for crops with higher or lower net earnings per acre-foot and (b) looser constraints on out-of-district sales.

An additional scenario considers the potential for market-based reallocation to complement the other components of the Integrated Plan. This scenario assumes that those components will provide proratable irrigators in the five districts with 60 percent of their full entitlement and estimates the potential for market-based trading to offset the irrigation-related economic losses that otherwise would occur at this level of water availability.

1.1 Experience in the Basin with Market-Based Transactions

Water users in the Yakima River Basin and elsewhere have used market-based transactions to offset the impacts of severe droughts and accommodate growth in competing demands for water. In May 1994, Reclamation implemented the Emergency Water Transfer Program, a one-year, demonstration project aimed at determining if water could be reallocated to where it would be most beneficial, giving irrigators additional opportunities to sustain valuable crops, such as orchards, when water supplies are extremely short. Reclamation received a total of nine formal transfer requests, and approved eight that transferred about 1,600 ac-ft. In 1996, Reclamation executed the first lease of an irrigation water right for instream flows in the Yakima River Basin, under its water acquisition program to restore flows for salmon habitat. The transfer occurred on a tributary, the Teanaway River.

In 1989 the Legislature enacted the Yakima Basin Trust Water Rights Act, and expanded the program in 1991 so that a whole or portion of an existing water right can be transferred permanently or temporarily to the state for beneficial uses, such as irrigation, instream flow, industrial, and municipal.

In 2001, a drought year, water managers and major stakeholder groups in the basin formed the Water Transfer Work Group (WTWG), a voluntary effort to provide expedited technical review of proposed water right transfers in the Yakima River basin. The WTWG process guides applicants to the types of water right changes and transfers that the state can quickly and easily approve. In 2005, also a drought year, the WTWG facilitated the transfer of about 49,000 acre-feet of water (Ecology 2005).

Also in 2005, Ecology conducted its first reverse auction for acquiring water in the Yakima River basin. Reverse auctions are different from typical auctions in that they are run by the buyer, rather than the seller. In a reverse auction the prospective buyer (Ecology) announces its intention to lease or purchase water rights and requests that potential sellers submit bids identifying the price at which they are willing to lease or sell water rights. Ecology sets criteria—such as location, priority date, price, and the “value of the stream affected”—it will use to decide if it will accept a bid. Once the bidding deadline has passed, Ecology uses the criteria to rate and select offers. Reverse auctions have yielded mixed results (Barwin 2010 personal communication).

In the 2005 reverse auction, Ecology accepted five offers, resulting in leases for a total of 4764.6 ac-ft. In 2007, Ecology held a second reverse auction, intended to provide a portfolio of leases, dry-year options, and purchases for improving flows, water quality and fish habitat in tributary streams and the lower Yakima River. Ecology had \$500,000 available to lease or buy water rights, but it received few bids, and none that satisfied its criteria. In 2008, Ecology and the Washington Rivers Conservancy conducted a reverse-auction that resulted in the purchase of water rights that will be dedicated to instream flow in Manastash Creek in perpetuity. The purchase will increase flow by about 3 cubic feet per second (cfs) and 937 acre-feet per year.

In 2009, Reclamation and Ecology executed a contract to facilitate voluntary transfers of up to 1,000 acre-ft of water within the Yakima Project. Reclamation will store up to 1,000 acre-ft of water on behalf of Ecology and make it available for Ecology to provide to domestic and municipal water users whose

post-1905 water rights are insufficient to meet demands. In exchange, Ecology will acquire, by voluntary transfer, an equal amount of senior water rights and hold them in the Trust Water Program. Ecology's payment to Reclamation for the storage and delivery services is initially set at \$22.00 per acre-foot.

In 2010, Suncadia, a private business developing a resort near Cle Elum, and Ecology finalized an agreement that transferred 163 ac-ft of consumptively used water, with an 1884 water right, to be made available through a water banking program to about 2,000 homes in the upper Kittitas Valley that would use groundwater and must mitigate the impacts of their water use on streamflows and senior water rights (Ecology and Suncadia 2010). In addition, a private business, SC Aggregate, and Ecology entered into a water-banking agreement for 166 ac-ft of consumptively used water under an 1884 water rights that once served the Reecer Creek Golf Course (Ecology and SC Aggregate 2010). This water right transfer is intended to enable residential development relying on groundwater in the Ellensburg area, by mitigating the effect of new wells on senior water rights.

Washington Water Trust has completed several transfers in the Yakima River Basin. One restored 28.8 cfs to Taneum Creek by substituting ground water for surface water (Washington Water Trust). Another, through a partnership with the Cowiche Canyon Conservancy, North Yakima Conservation District, and Washington Department of Fish and wildlife, permanently transferred 1.43 cfs to Cowiche Creek (Washington Water Trust).

1.2 Experience Elsewhere with Market-Based Transactions

McCrea and Niemi (2009) summarized information about programs in seven western states that promote market-based reallocation of water resources. Some of them provide insights applicable potentially applicable to the Yakima River Basin:

- In Colorado water markets have flourished. Much of the activity is attributed to the widespread adjudication of water rights and the water court system. Water courts are district courts, analogous to superior courts in Washington State, which conduct general business of the district court but also specialize in water cases. An application to transfer a water right is submitted to the court, which assigns it to a water referee, who referee investigates the truth of the statements in the application and any statements in opposition, and consults with the division engineer for the region where the court operates. Approximately 95 percent of the applications are settled at the referee level without a court hearing.
- In response to drought conditions, the Palo Verde Irrigation District (PVID), which diverts and distributes water from the Colorado River, agreed in 1992 to serve as a broker between individual irrigators in the district and the Metropolitan Water District (MWD), which serves the coastal communities of southern California. Under the agreement, PVID reaches agreements with irrigators to fallow, on a rotating basis, up to 25 percent of the land within its service territory and it then transfers to MWD the water that otherwise would be consumed for \$135 per acre-foot. A more lasting agreement, signed in 2004, establishes the maximum acreage to be fallowed in PVID at 28 percent of the total, and establishes the long-term price at \$602/acre-foot (annually adjusted for inflation). Participating irrigators also receive an initial sign-up payment of \$3,170/acre.
- The Deschutes River Conservancy (DRC) is comprised of representatives from private and public interests in Oregon's Deschutes River Basin. In collaboration with landowners, agencies, and other organizations, the DRC employs auctions and other market-based tools to promote ecological restoration and support growing communities. Through temporary leases, permanent transfers, and conservation projects, it restored more than 100 cfs of flow to the Middle Deschutes River downstream of Bend in 2006. Although it has received federal funding, it

currently relies on contributions from individuals, businesses, corporations, philanthropic foundations, and government agencies.

2.0 Summary of the Potential for Market-Based Transactions to Offset Impacts of Future Severe Drought

The first step in estimating the effects of the Integrated Plan is to estimate the losses irrigators would incur from future droughts without the plan. The top two lines of Table 1 show the modeling results. With no drought, irrigators in Kittitas, Roza, Sunnyside, Tieton, and Wapato Districts would realize annual net farm earnings (crop receipts minus variable costs) of about \$280 million.² During a future, severe drought year (defined here as proratable irrigators receiving 40 percent of full entitlement) and without any trading, annual net farm earnings would fall to about \$200 million.³ Under the baseline scenario, without implementation of the Integrated Plan, irrigators would lease about 30,000 acre-feet of water to other irrigators, and the five districts would realize overall annual net farm earnings of about \$220 million. The irrigation-related economic losses, measured as reductions in annual net farm earnings, would total about \$60 million.

Table 1 also shows the potential for additional market-based reallocation of water, implemented as a constituent of the Integrated Plan, to offset the irrigation-related economic losses from future droughts. Under the core scenario, the market-based reallocation element of the Integrated Plan operating in a stand-alone manner has the potential to increase annual net farm earnings during a severe drought year to about \$260 million, about \$40 million more than without the Integrated Plan. Under this scenario, intra-district sales would equal 130,000 acre-feet, inter-district sales would rise from 30,000 to 50,000 acre-feet, and the irrigation-related economic losses from the severe drought would total about \$20 million.

Several alternative scenarios show the sensitivity of the results to changes in assumptions about the constraints on out-of-district sales for Roza, Kittitas, and Sunnyside Districts, and about the crops receiving water. Relaxing the constraint on out-of-district sales so they can be no more than 30 percent rather than 10 percent of water supply, would result in intra-district trades of 110,000 acre-feet, inter-district trades of 90,000 acre-feet, and total annual net farm earnings of about \$270 million. Constraining buyers to leasing water only for crops with net earnings of \$300 rather than \$150 per acre-foot would lower the amount of intra-district trades from 130,000 to 100,000 acre-feet compared to the core scenario, but inter-district trades and total annual net farm earnings would remain the same as in the core scenario. Conversely, relaxing the constraint so buyers could lease water for crops with net earnings smaller than \$150 per acre-foot crop would raise the intra-district trades to 230,000 acre-feet while the volume of inter-district trades would remain unchanged at 50,000 acre-feet, and the districts' overall annual net farm earnings would rise to about \$270 million.

² Throughout this report, where appropriate, net farm earnings are rounded to the nearest ten million, and water traded is rounded to the nearest ten thousand.

³ To facilitate the analysis of market-based transactions, this technical memorandum assumes that, during a severe drought year proratable irrigators receive 40 percent of full entitlement, which is representative of recent droughts. Subsequent analysis of the economic effects of the Integrated Plan draws on hydrologic modeling of future conditions and assumes that proratable irrigators would receive 30 percent of full entitlement during future severe droughts.

Table 1. Summary of Findings: Potential Water Trading and Impact on Annual Net Farm Earnings in a Severe Drought Year

SCENARIO ^b	WATER TRADED (acre-feet)		TOTAL ANNUAL NET FARM EARNINGS (\$MIL)	
	INTRA-DISTRICT	INTER-DISTRICT	TOTAL	LOSS FROM DROUGHT
Average Non-Drought Year	Zero	Zero	\$280	Zero
Severe Drought, No Trading	Zero	Zero	\$200	–80
Severe Drought ^a , without the Integrated Plan	Zero	30,000	\$220	–\$60
Severe Drought^a, with Only the Market-Based Component of the Integrated Plan				
<i>Core Scenario^c</i>	130,000	50,000	\$260	–\$20
<i>Alternative Scenarios^d</i>				
A. Looser Constraint on Out-of-District Sales (30%)	90,000	110,000	\$270	–\$10
B. Acquisitions for Higher-Value Crops (at least \$300/acre-foot)	100,000	50,000	\$260	–\$20
C. Acquisitions Allowed for Lower-Value Crops (Open Trading)	230,000	50,000	\$270	–\$10
Severe Drought, if other Components of the Integrated Plan Provide 60% of Proratable Entitlement				
<i>No Trading</i>	Zero	Zero	\$240	–\$40
<i>Without Market-Based Transactions</i>	Zero	30,000	\$260	–\$20
<i>With the Market-Based Core Scenario</i>	60,000	60,000	\$280	–\$10

^a Severe drought year provides proratable irrigators with 40 percent of full entitlement.

^b All scenarios assume only intra-district trading for Wapato, and Tieton Districts; intra- and inter-district trading for Roza, Kittitas, and Sunnyside Districts.

^c Core-scenario assumptions: all irrigators are willing to sell water from lower-value to higher-value crops; buyers lease water only for crops with annual net farm earnings of \$150 per acre-foot; and no more than 10 percent of the water supply for Roza, Kittitas, and Sunnyside districts during a severe drought year can be leased out of the district.

^d Core assumptions apply, except the change indicated in each alternative scenario.

The bottom three lines of Table 1 show the potential for market-based transactions to complement other components of the Integrated Plan. They represent a scenario where those components limit the effects of a future severe drought so the water supply for proratable irrigators falls to only 60 percent of their full entitlements rather than to 40 percent as in the core scenario. If no trading were to occur, the districts’ annual net farm earnings would total about \$240 million. If the baseline level of 30,000 acre-feet were traded, the districts’ annual net farm earnings would rise to about \$260 million.

Implementation of the market-based element of the Integrated Plan has the potential to raise annual net farm earnings to about \$280 million by allowing for intra- and inter-district trades of 60,000 acre-feet each.

3.0 Potential Market-Based Activity and Economic Effects of Severe Drought without the Integrated Plan

This section describes the potential effects of future severe drought conditions on irrigation-related annual net farm earnings, the amount of market-based activity anticipated in the future under the baseline scenario (without the Integrated Plan), and the extent to which the baseline level of market-based activity would offset the effects.⁴

Table 2 shows that the total annual net farm earnings for the five districts during an average non-drought year is about \$280 million. No drought-related trading occurs in such years because the available water supply is adequate to satisfy crop-irrigation requirements. Net farm earnings equal the expected crop receipts minus the annual variable costs of producing the crop such as seeds, labor, and fuel.⁵ They represent the net economic benefits farmers in the districts realize from producing irrigated crops. Hence, a reduction in annual net farm benefits represents the net economic loss they incur when water supplies fall below their full crop-irrigation requirements.

Table 2 also shows the earnings in the five districts for drought years at various levels of prorationing. The irrigation community has identified prorationing of not less than 70 percent as a goal for drought years (see vol. 2 technical memorandum: *Water Needs for Out-of-Stream Uses*). Annual net farm earnings are expected to decline as drought severity intensifies. At the level that is the focus of this analysis, with proratable irrigators receiving 40 of their full entitlement, annual net farm earnings for the five districts would fall to about \$200 million with no trading. With the baseline trading level of 30,000 acre-feet, annual net earnings would total about \$220 million. At higher levels of water availability, the annual net farm earnings would rise, both with and without the baseline level of trading.

The estimates in Table 2 and in the remainder of this memorandum are derived from an analytical model that simulates the transfer of water from a crop with lower annual net farm earnings per acre-foot to a crop with higher earnings. The analytical model builds on one developed by researchers at the Pacific Northwest National Laboratory,⁶ with adjustments reflecting the current understanding of water supplies, rights, uses, and conveyance losses from the vol. 2 technical memorandum: *Water Needs for Out-of-Stream Uses*. It also reflects detailed, crop- and district-specific opportunities for increasing annual net farm earnings by transferring water from a crop with lower net earnings to one with higher net earnings.

⁴ This analysis does not examine the effects of anticipated trading outside the Yakima Project. Future years will see more water trading in the Yakima River basin than in the past, even without implementation of the Integrated Plan. By 2040, irrigators outside the Yakima Project likely will sell water rights (consumptive use) sufficient to transfer:

- Up to 50,000 acre-feet of water per year to mitigate for the effects of post-1905 residential development.
- About 5,000 acre-feet of additional water per year for environmental purposes.
- About 2,000 acre-feet per year to other irrigators growing higher-value crops.

⁵ Under non-drought conditions, annual gross farm earnings will be about \$1,060 million, or 3–4 times annual net farm earnings.

⁶ We gratefully acknowledge the assistance of Michael Scott at the PNW National Laboratory for his assistance in providing access to the model. ECONorthwest is solely responsible for how the model was used in this analysis.

Table 2. Annual Net Farm Earnings at Different Levels of Drought, with and without Baseline Trading (\$million)

DROUGHT SEVERITY (% OF PRORATABLE ENTITLEMENT)	NET FARM EARNINGS WITH NO TRADING	WITH BASELINE TRADING (30,000 ACRE-FEET)
Average Non-Drought Year	\$280	\$280*
70%	\$260	\$280
60%	\$240	\$260
50%	\$220	\$240
40%	\$200	\$220

Source: ECONorthwest.

* No trading would occur during an average non-drought year.

The analysis assumes that only intra-district trading could occur in Wapato and Tieton Districts when the available water supply does not satisfy crop-irrigation requirements, but that intra- and inter-district trading could occur in Roza, Kittitas, and Sunnyside Districts, subject to a constraint on the percentage of water supplies that can be sold out of each district. It also assumes that current cropping patterns and annual net farm earnings per crop remain unchanged. The appendix describes details of the analysis and shows crop-related data inputs.

Table 3 shows the irrigable acreage, anticipated crop-irrigation requirements, and annual supply of water under severe-drought conditions for each district without the Integrated Plan. During average non-drought conditions, irrigators in the five districts would use 1,674,000 acre-feet to satisfy crop-irrigation requirements. During severe drought conditions, the total supply of water would fall to 1,169,000 acre-feet, or 505,000 acre-feet below the districts' full crop-irrigation requirements. The irrigation community has consistently identified a goal of obtaining 70 percent of entitlements during drought years, but this target applies only to proratable irrigators, and the shortfall during severe drought years has been estimated to be 355,400 acre-feet (see vol. 2 technical memorandum: *Water Needs for Out-of-Stream Uses*) If irrigators concentrate their water supplies to satisfy the crop-irrigation requirements of higher-value crops as much as possible and leave other lands fallow, about 110,000 acres would be fallowed under severe drought conditions.

Table 3. Acreage, Crop-Irrigation Requirements, and Water Supply during a Future Severe Drought Year without the Integrated Plan, by District

DISTRICT	TOTAL ACRES	FULL CROP-IRRIGATION REQUIREMENTS ^a (ac-ft)		SEVERE DROUGHT WATER SUPPLY ^b (ac-ft)	
		NONPRORATABLE	PRORATABLE	NONPRORATABLE	PRORATABLE
Roza	72,000	-	320,000		157,000
Kittitas	56,000	-	286,000		134,000
Sunnyside	99,000	290,000	139,000	290,000	63,000
Wapato	110,000	306,000	254,000	306,000	140,000
Tieton ^c	22,000	76,000	3,000	76,000	3,000
Total	360,000	672,000	1,002,000	672,000	497,000

Source: ECONorthwest. Totals may not equal the sum of district numbers because of rounding.

^a From volume 2 technical memorandum: *Water Needs for Out-of-Stream Uses*.

^b Assumes that during severe drought conditions proratable irrigators would receive 40 percent of full entitlement. Proratable entitlements in acre-feet are: Roza 393,000, Kittitas 336,000, Sunnyside 157,776, Wapato 350,000, and Tieton 30,425. Also see note (c) below.

^c Assumes that Tieton District, during a severe drought year, would divert for proratable use no more than what it diverts, on average, during a non-drought year. This amount is less than 40 percent of the district's full proratable entitlement.

Table 4 shows expected annual net farm earnings for each of the five irrigation districts under baseline conditions without the Integrated Plan. Under anticipated future non-drought conditions, annual net farm earnings for the five districts would total about \$280 million. This would fall to about \$200 million with no trading, and to about \$220 million with the trading of 30,000 acre-feet that would occur without the Integrated Plan.⁷ The estimates reflect the assumptions of the core scenario: that buyers would acquire water only for crops with annual net farm earnings of at least \$150 per acre-foot, and that out-of-district sales for each district would not exceed 10 percent of available water supplies for Roza, Kittitas, and Sunnyside.

Table 4. Irrigators’ Annual Net Farm Earnings during Non-Drought and Severe Drought Years without the Integrated Plan, by District

DISTRICT	ANNUAL NET FARM EARNINGS (\$Million)		
	NON-DROUGHT	SEVERE DROUGHT, ^a NO TRADING	SEVERE DROUGHT, TRADING 30,000 AC-FT ^b
Roza	\$90	\$50	\$60
Kittitas	\$9	\$4	\$5
Sunnyside	\$70	\$50	\$60
Wapato	\$80	\$60	\$60
Tieton	\$40	\$40	\$40
Total	\$280	\$200	\$220

Source: ECONorthwest. Totals may not equal the sum of district numbers because of rounding.

^a Severe drought conditions provide proratable irrigators with 40 percent of their full entitlement.

^b The amount, 30,000 acre-feet, that would be traded during severe drought without the Integrated Plan.

4.0 Market-Based Activity and Economic Effects of Severe Drought with the Integrated Plan’s Market-Based Reallocation

This section describes the potential for the market-based element of the Integrated Plan to offset the irrigation-related economic losses from a severe drought. The discussion first addresses the potential effects of market-based reallocation in isolation, then discusses its potential to complement the effects of other components of the Integrated Plan.

4.1 Market-Based Element in Isolation

This section estimates potential market-based activity that might take place if the Integrated Plan were to reduce agricultural losses during a severe drought by stimulating additional market-based reallocation of water beyond the level anticipated in the baseline scenario without the Integrated Plan. Focusing on five of the Yakima Project’s irrigation districts (excluding the Kennewick District where trading is not anticipated), it first describes the economic effects of the market-based element under the core scenario that embodies expectations about future market conditions. It then examines the extent to which the economic effects might vary under different assumptions about market conditions.

The core scenario embodies these assumptions:

⁷ These estimates roughly correspond to the findings of an analysis of the economic consequences of the 2001 drought, when proratable irrigators received 37 percent of their full entitlement (Northwest Economic Associates 2004). It found that the drought resulted in reductions of annual crop revenues of about \$130 million and growers’ profits of about \$96 million. The estimates presented here are not strictly comparable because the earlier analysis considered a higher supply of water for proratable irrigators, used different data for crop prices and other variables, and accounted for the costs farmers incurred by taking actions, such as pumping groundwater and water transfers, to mitigate the effects of the drought.

- Severe drought conditions reduce the water availability for proratable irrigators to 40 percent of their full entitlement.
- To offset the economic losses from the drought, all irrigators within the five districts are willing to sell water through short-term leases so it moves from a crop with lower annual net farm earnings per acre-foot to one with higher earnings.
- Buyers acquire water only for crops with net earnings greater than \$150 per acre-foot: other vegetables, wine grapes, apples, other grains, hops, and potatoes. (The discussion in the appendix shows the annual net earnings by crop.)
- Only intra-district transfers can occur in Wapato and Tieton districts, but both intra- and inter-district transfers can occur in Roza, Kittitas, and Sunnyside districts.
- Sales of water out of Roza, Kittitas, and Sunnyside Districts cannot exceed 10 percent of each district’s annual water supply during a severe drought (rounded to nearest 1,000 acre-feet): Roza (16,000 acre-feet), Kittitas (13,000 acre-feet), and Sunnyside (35,000 acre-feet).

Alternative scenarios examine the effect of (a) loosening the constraint on out-of-district sales to 30 percent of each district’s water supply, (b) allowing buyers to acquire water only for crops that yield annual net farm earnings of at least \$300 per acre-foot, and (c) allowing buyers to acquire water for all crops (open trading, subject only to the constraint on out-of-district sales).

Table 5 shows the amount of intra- and inter-district water traded, and the annual net farm earnings for the core scenario and the three alternatives. In the core scenario, Roza would receive about 13,000 acre-feet from Kittitas, and about 35,000 acre-feet from Sunnyside.

Table 5. Water Traded and Annual Net Farm Earnings during a Severe Drought with only the Market-Based Element of the Integrated Plan – Core Scenario and Alternative Scenarios

SCENARIO	WATER TRADED (ACRE-FEET)		ANNUAL NET FARM EARNINGS (\$MILLION)
	INTRA-DISTRICT	INTER-DISTRICT	
Core Scenario ^a	130,000	50,000	\$260
<i>Alternative Scenarios^b</i>			
A. Looser Constraint on Out-of-District Sales (30%)	90,000	110,000	\$270
B. Acquisitions for Higher-Value Crops (at least \$300/acre-foot)	100,000	50,000	\$260
C. Acquisitions Allowed for Lower-Value Crops (Open Trading)	230,000	50,000	\$270

Source: ECONorthwest.

^a Assumes irrigators trade water freely, buyers acquire water only for crops with net earnings greater than \$150/ac-ft; only Roza, Kittitas, and Sunnyside Districts participate in inter-district trading; and the total out-of-district sales (including sales that would occur without the Integrated Plan) cannot exceed 10 percent of the supply of water available for Roza, Kittitas, and Sunnyside Districts.

^b Assumptions of the core scenario apply, except the change indicated in each alternative scenario.

4.2 Market-Based Element Complements Other Components of the Integrated Plan

This section describes the potential for market-based transactions to complement the other components of the Integrated Plan in offsetting irrigation-related economic losses during a severe drought. Table 6 shows the results of the analysis, which assumes that the other components would provide proratable irrigators enough water to meet 60 percent of their full entitlement. The top line in Table 6 shows the

amount of water traded (zero) and the annual net farm earnings under the Integrated Plan with no trading. The second line shows the results assuming that trading would occur, but only at the baseline level (30,000 acre-feet). The third line shows the results assuming that trading would occur under the conditions of the core scenario.

These results indicate that market-based transactions, when combined with the other components of the Integrated Plan, have the potential to fully offset irrigation-related economic losses from future severe drought conditions. Under the core scenario, Roza would receive about 20,000 acre-feet from Kittitas, and about 38,000 acre-feet from Sunnyside.

Table 6. Water Traded and Annual Net Farm Earnings during a Severe Drought with Market-Based Transactions Complementing Other Components of the Integrated Plan

SCENARIO	WATER TRADED (ACRE-FEET)		ANNUAL NET FARM EARNINGS (\$MILLION)
	INTRA-DISTRICT	INTER-DISTRICT	
No Trading	Zero	Zero	\$240
Without Market-Based Transactions	Zero	30,000	\$260
With the Market-Based Core Scenario ^a	60,000	60,000	\$280

Source: ECONorthwest.

^a Assumes irrigators trade water freely, buyers acquire water only for crops with net earnings greater than \$150/ac-ft; only Roza, Kittitas, and Sunnyside Districts participate in inter-district trading; and the total out-of-district sales (including sales that would occur without the Integrated Plan) cannot exceed 10 percent of the supply of water available for Roza, Kittitas, and Sunnyside Districts.

5.0 Summary

These analytical results suggest that, by itself, the market-base element of the Integrated Plan has the potential to offset much, but not all, of the irrigation-related economic losses from a future severe drought. It also has the potential to totally offset the losses when working in conjunction with other components of the plan.

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7.0 List of Preparers

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Appendix: Details of the Analysis

This appendix describes the methods, data, and assumptions incorporated into the analysis of the Market Reallocation element of the Integrated Plan.

The analysis employs a spreadsheet model that identifies the allocation of available water across crops and districts, given identified constraints, that would maximize annual net farm earnings under optimal market conditions. The model structure is adapted from one developed by researchers at the Pacific Northwest National Laboratory, who used it to describe opportunities for market-based transfers to mitigate the impacts of drought on agricultural production in the Yakima River basin and to increase the overall value of agricultural earnings derived from the basin's water resources. They also used the model to investigate potential impacts of anticipated climate change on the value of agricultural production and the ability of market-based transfers to mitigate adverse impacts.

The analysis embodies the findings of recent research relevant to this assessment (Vano et al. 2009, Willey and Diamant 1994, Huppert, D. et al. 2004, Williams and Capps 2005, Northwest Economic Associates 1997, Scott, M.J, et al. 2004, Northwest Economic Associates 2004) It also embodies several assumptions about the extent of market-based transfers without the Integrated Plan. Background assumptions include: (a) sufficient voluntary transfers from agriculture will occur so water shortages do not constrain municipal/domestic growth, with the water coming from irrigators outside the Yakima Project; (b) current or foreseeable economic trends forecasted by local and state governments will continue over the study period; and (c) demand for environmental uses of water and to improve the quality of life for residents and visitors will grow faster than demand associated with irrigated agriculture.

The model considers the 17 crops shown in Table A-1. The table also shows inputs to the model for each crop, and traces the calculation of net earnings per acre-foot, by crop. Inputs to the model come from the Pacific Northwest National Laboratory and original data sources such as the individual districts and the Washington State Department of Agriculture used in the volume 2 technical memorandum: *Water Needs for Out-of-Stream Uses*.

The numbers in the table reflect the most current data available. For most variables, the data have been updated to at least 2008. In some instances data were not available for each crop. Gaps in the data were filled with data for a similar crop, following the pattern of substitutions adopted by the researchers at the Pacific Northwest National Laboratory. The analysis assumes that these substitutions reasonably represent the characteristics of the different crops.

The analysis also assumes that the characteristics of the different crops and, hence, the net earnings, will remain constant during the study period. In actuality, some irrigators in the basin likely will alter the mix of crops and experience variation in variable costs, crop prices, and crop-irrigation requirements. The net earnings likely will increase for some crops and decrease for others.

The estimates of net earnings reflect the estimated average value of the full irrigation requirement for each crop. The analysis assumes that this value applies to changes in water availability. For some crops, it may be possible to estimate the change in net earnings associated with incremental changes in water availability, but the activities necessary to acquire the necessary data and integrate them into the spreadsheet model lie outside the scope of this project. Actual annual net farm earnings for water may be higher than the average, especially as water availability declines to levels that threaten the survival of perennial crops.

The model does not simulate each individual transaction, but, rather, identifies the efficient endpoint of all transactions, given a set of constraints. It identifies the direction and magnitude of trades by comparing the outcomes of scenarios with varying constraints and varying levels and types of trades. To

estimate inter-district trades, subject to a constraint on out-of-district sales, the model first allows intra-district trades until the mandatory minimum supply of water to be used in a district has been exhausted, and then opens the remaining water to inter-district trades.

Table A-1. Net Earnings per Acre-Foot, by Crop, and Inputs to the Model

CROP	OUTPUT UNITS	(1) ANNUAL VARIABLE COST (\$/AC)	(2) AVERAGE YIELD (UNITS/AC)	(3) AVG. PRICE (\$/UNIT)	(4) ^A ANNUAL NET FARM EARNINGS (\$/AC)	(5) WATER DEMAND (AC-FT/AC)	(6) ^B ANNUAL NET FARM EARNINGS (\$/AC-FT)
Other Vegetables	cwt/ac	\$2,037	500.0	\$12	\$3,960	3.8	\$1,050
Wine Grapes	t/ac	\$1,949	4.0	\$919	\$1,730	3.5	\$490
Apples	t/ac	\$6,453	16.1	\$537	\$2,170	5.4	\$400
Other Grain	bu/ac	\$563	141.5	\$14	\$1,430	3.5	\$410
Hops	lb/ac	\$2,489	1976.2	\$2	\$1,120	4.0	\$280
Potatoes	cwt/ac	\$2,037	546.1	\$6	\$940	4.8	\$200
Concord Grapes	t/ac	\$1,071	8.6	\$185	\$520	3.7	\$140
Miscellaneous	bu/ac	\$323	200.0	\$4	\$480	4.5	\$110
Other Tree Crops	t/ac	\$6,453	13.6	\$510	\$480	5.7	\$80
Sweet Corn	cwt/ac	\$427	193.9	\$4	\$260	3.2	\$80
Asparagus	cwt/ac	\$1,817	37.2	\$59	\$360	4.7	\$80
Mint	lb/ac	\$1,217	124.9	\$13	\$390	6.0	\$70
Other Hay	t/ac	\$323	4.7	\$115	\$220	5.4	\$40
Timothy Hay	t/ac	\$327	3.8	\$124	\$140	5.6	\$30
Wheat	bu/ac	\$323	103.4	\$4	\$90	3.8	\$20
Alfalfa Hay	t/ac	\$547	5.6	\$98	\$1	5.2	\$0.1
Pasture	t/ac	\$323	4.7	\$51	\$(80) ^C	4.5	\$(20) ^C

Source: ECONorthwest, with data from the PNW National Laboratory; and from original data sources reported in the volume 2 technical memorandum: *Water Needs for Out-of-Stream Uses*.

^a [Column (2) times column (3)] minus column (1). Numbers reflect rounding.

^b Column (4) ÷ column (5). Numbers reflect rounding

^c Numbers in parentheses represent a net loss.