Retiming Benefits Analysis for Conservation in the Walla Walla, Horse Heaven Hills and Southern Franklin County Study Areas

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Project Support

- Funding & Acknowledgements:
  - Department of Ecology
  - Washington State Conservation Commission
  - Franklin Conservation District
    - Project Manager: Mark Nielson
  - Many Other Cooperators
    - Walla Walla Conservation District, WWBWC
    - Bureau of Reclamation, Army Corps of Engineers
    - Franklin County Irrigation District
    - Faculty/Researchers at WSU, Whitman College, PNNL Hanford
- Report finalized in February; available from Ecology

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Purpose of the Investigation

Provide a technically defensible analysis of the extent to which irrigation conservation could create new water availability in the Columbia River

Particular focus on the "re-timing" of availability of the portion of irrigation water that percolates beyond the root zone, recharges the ground-water system (via "deep percolation"), and returns to the river.

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Criteria for Demonstration Areas

1. Common Use of Lower Efficiency Irrigation Methods
2. Far Enough from River to Support Significant Retiming of Subsurface Return Flow
3. Surface Water Irrigation Source
4. Water Rights Outside Columbia Irrigation Project
5. Hydrogeology Relatively Well Understood
6. Potential for Multiple Conservation Projects in Area

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3 Selected Demonstration Areas

- Walla Walla, Horse Heaven Hills, Southern Franklin County (Pasco Basin)
- None Meet All 6 Criteria (Compromises Made)
- Others May Follow (Demonstrate "Proof of Concept")

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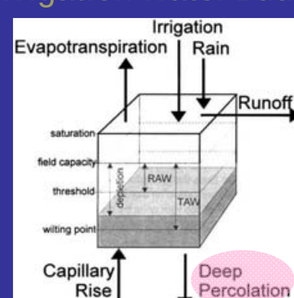
Irrigation Water Budget



Deep Percolation & Runoff are *Non-Consumptive*

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How to Reduce Deep Percolation

- Use Most Efficient Irrigation Methods
  - Center Pivot w/ Low Energy Precise Application (LEPA)
- Use Irrigation Water Management (IWM)
  - Tracks Irrigation, Precipitation & Soil Moisture Levels to Avoid Over-Application
  - Can Reduce Crop Requirement by up to 17%
  - Increased Efficiency Largely Reduces Deep Percolation
- Total Irrigation Savings > 17%

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Associated Benefit to Streamflow

- Reduced Diversion Over Irrigation Season
  - Reduced Evaporative Loss (Consumptive)
  - Reduced Deep Percolation (Non-Consumptive)
  - Reduced Runoff (No Net Benefit)
- How Can Reducing a Non-Consumptive Use Provide a Net Benefit?
  - Columbia River critical Period July-August (RCW 90.90)
  - "Retiming" Water Availability via Subsurface Return Flow
  - More Water Available During Critical Period

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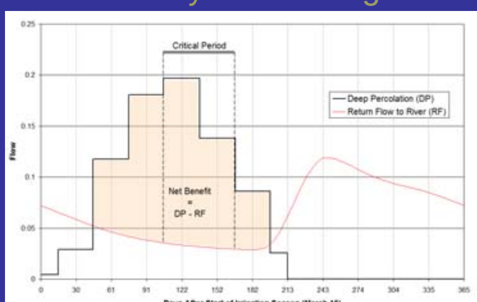
Theory of Retiming



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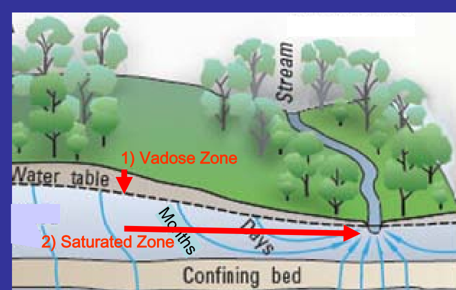
Subsurface Return Flow



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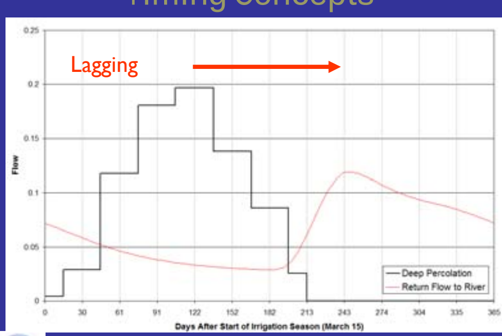
Timing Concepts



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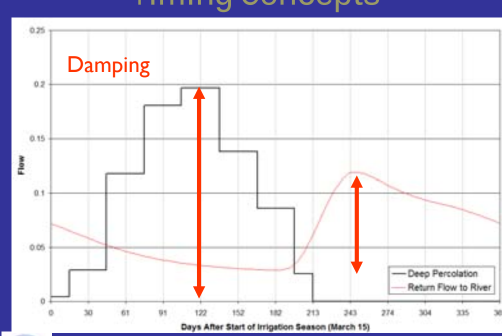
Timing Concepts



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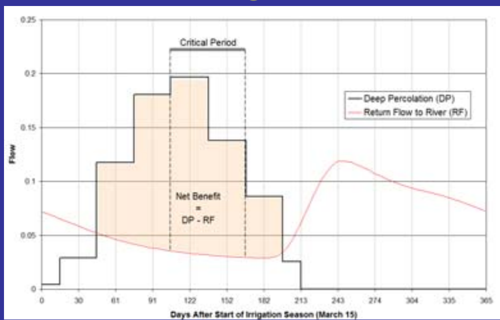
Retiming Benefit



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Case Study: SFC Study Area

- Three Hypothetical Sites Modeled
  - 2 CBP Sites Irrigated with River Water
  - 1 "Greenbelt" Site Irrigated with Groundwater
- Irrigation Recharge
  - Estimated from CBP Records and Water Budget Analysis
  - Applied to Top of Vadose Zone
- Vadose Zone Retiming
  - Estimated with USDA "Hydrus-1D" Model
- Saturated Zone Retiming
  - Estimated with Calibrated USGS MODFLOW Model
  - Uncertainty Addressed via "Uncertainty Analysis"

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SFC Hypothetical Conservation Sites

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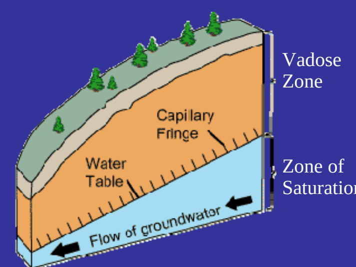
Vadose Zone

Hanford/Pasco Gravels



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Hanford Gravel Soil Textures

Formation	Soil Class	Code	Description	Hydrostratigraphic Unit Code(s)
Holocene Deposits	Backfill	Bf	Sand and gravel mixed with finer fraction. Same as the SSG soil category identified by Khaleel and Freeman (1995)	HDb
Hanford formation	Silty Sand	Hss	Sand mixed with finer fraction, containing >50% fine sands, silt, and clay, with >15% silt and clay. Derived from the SS soil category identified by Khaleel and Freeman (1995)	HISSD/HSD(f)
	Fine Sand	Hfs	Sand, containing 35-70% fine sand, silt, and clay, with <15% silt and clay. Derived from the S soil category identified by Khaleel and Freeman (1995)	HSD-Sm
	Coarse Sand	Hcs	Sand, containing >60% coarse sand. Derived from the S soil category identified by Khaleel and Freeman (1995)	HSD-Sh(c)
	Gravelly Sand	Hgs	Gravelly sand. Same as the GS soil category identified by Khaleel and Freeman (1995)	HSD(c)
	Sandy Gravel	Hg	Sandy gravel for which gravel content is approximately <60%. Same as the SG1 soil category identified by Khaleel and Freeman (1995)	HGD
	Gravel	Hrg	Very high gravel content soils (>60% gravel) from the 100 areas (along the river).	HGD(c)

Excerpted from Last, 2006

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Soil Hydraulic Characteristics

Site Wide									
Soil Class	Count	α (1/cm)	n	θ_R (cm³/cm³)	θ_s (cm³/cm³)	K_s (cm/sec)	S_r	% gravel	Bulk Density (g/cm³)
Bf	6	0.019	1.400	0.030	0.262	5.98E-04	0.103	33.5	1.94
Hss	38	0.008	1.915	0.072	0.445	8.58E-05	0.162	0.2	1.61
Hfs	36	0.027	2.168.	0.032	0.379	3.74E-04	0.086	0.6	1.60
Hcs	81	0.061	2.031	0.027	0.349	2.27E-03	0.080	2.6	1.67
Hgs	16	0.014	2.120	0.033	0.238	6.65E-04	0.140	25.8	1.94
Hg	28	0.017	1.725	0.022	0.167	3.30E-04	0.134	51.4	1.93
Hrg	40	0.007	1.831	0.020	0.102	1.46E-03	0.200	67.6	1.97
PPlz	9	0.005	2.249	0.040	0.419	5.57E-05	0.097	0.4	1.68
PPlc	14	0.011	1.740	0.054	0.281	8.45E-04	0.185	16.7	1.72
Rg	18	0.008	1.660	0.026	0.177	4.13E-04	0.135	46.1	1.90

Gravel Compensated VanGenuchten Parameters from Hanford studies, excerpted from Last, 2006

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Site Vadose Zone Characteristics

Block 1
155 feet of gravelly soils (upper limit Hrg)

Block 17
105 feet of sandy gravel (Hgs)

Greenbelt
65 feet of sandy gravel (Hgs)

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Hydrus-1D Simulations

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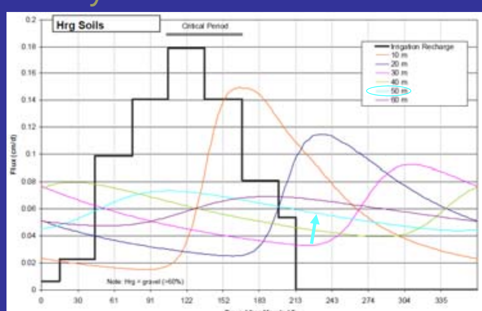
Hydrus-1D Simulations



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Groundwater Flow Modeling

- Used MODFLOW NWT (MF2005)
- Two Layers: Pasco Gravels & Middle Ringold Fmn.
- Features Include
  - Recharge from irrigation conveyances, wasteways, fields, precipitation
  - Irrigation pumpage (Pasco Greenbelt)
  - Surface-water features (Columbia & Snake Rivers, Coulees)
- Calibrated to Steady State & Transient
  - Pre-Development Steady State (1945)
  - Long-Term Transient (1945-1986)
  - Seasonal Transient (1986 monthly)
- Hydrus Data Used as Irrigation Recharge Input
- Predictive Simulations Include Uncertainty Analysis

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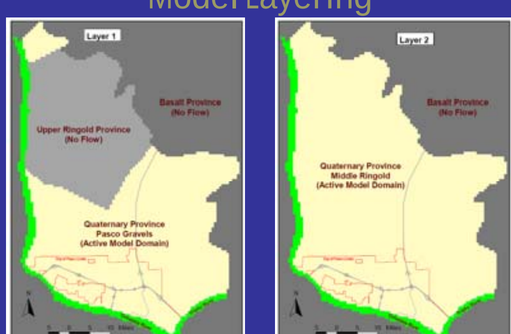
Model Layering



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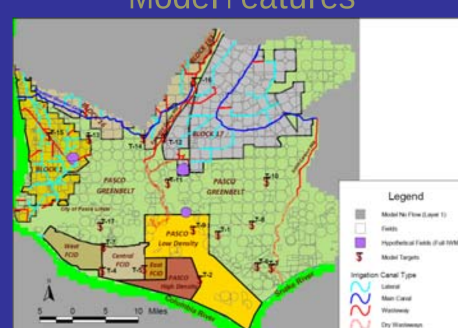
Model Features



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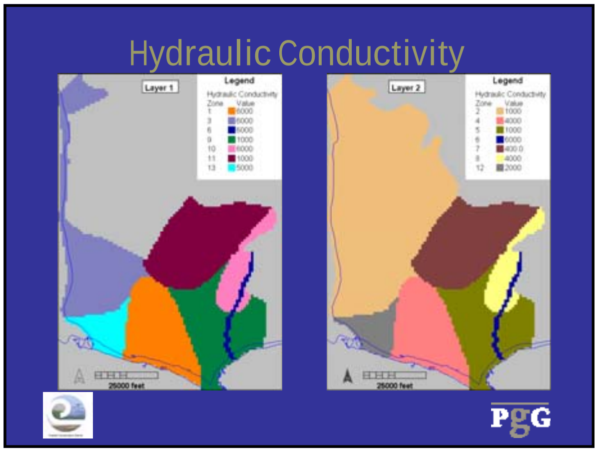
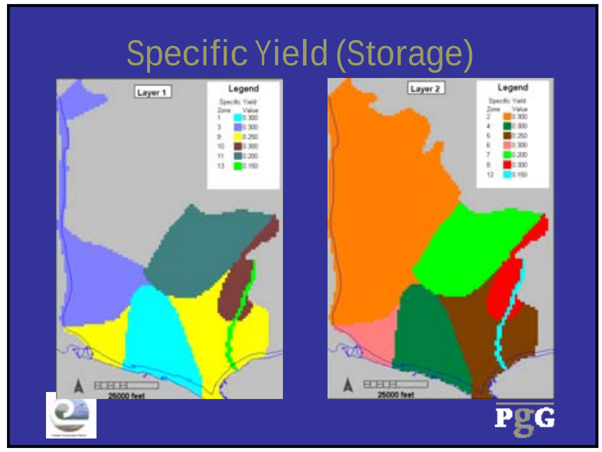
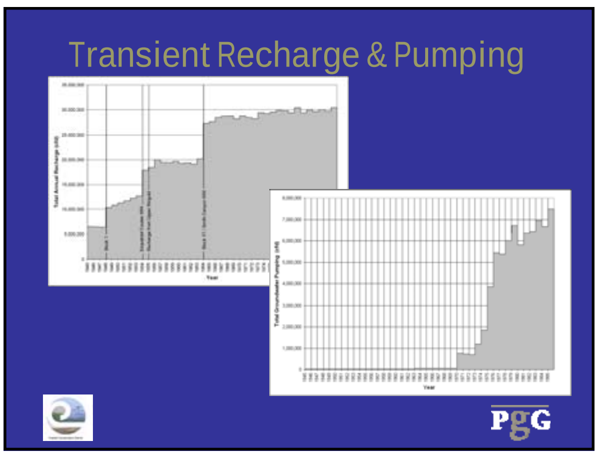
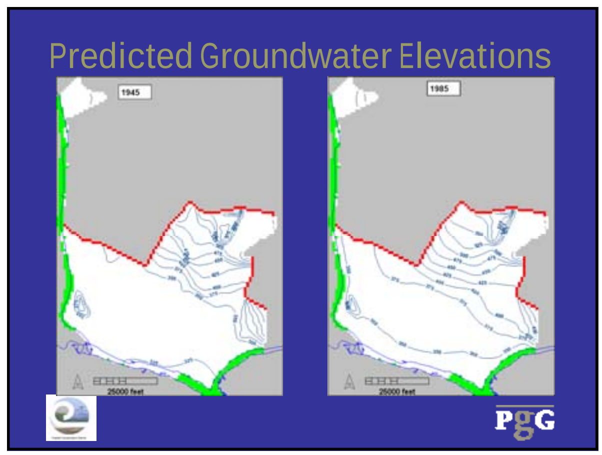
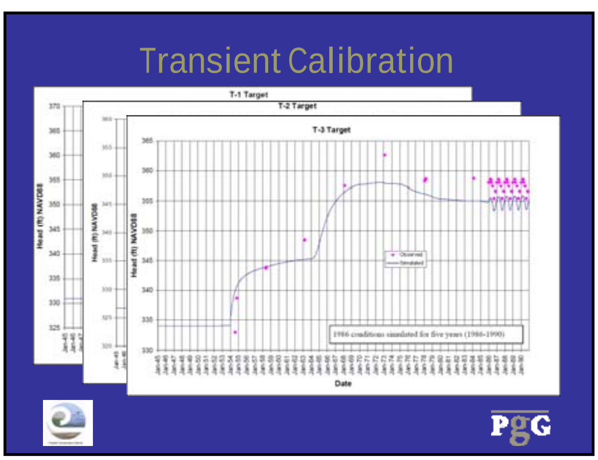
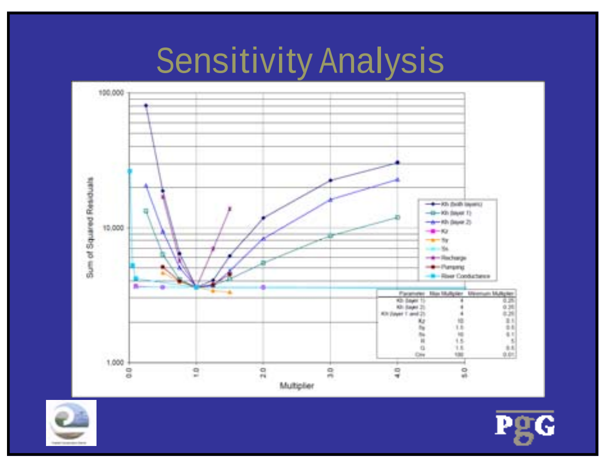

Hydraulic Conductivity
Layer 1
Legend
Layer 2
Legend
25000 feet


Specific Yield (Storage)
Layer 1
Legend
Layer 2
Legend
25000 feet

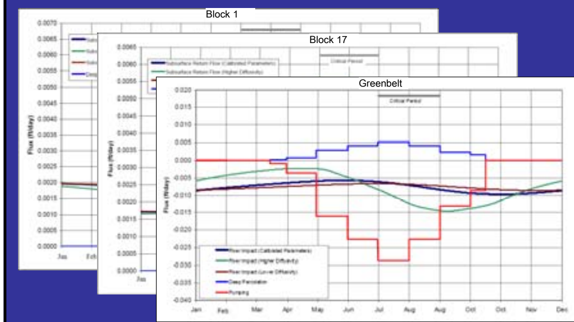

Transient Recharge & Pumping
Year


Predicted Groundwater Elevations
1945
1985
25000 feet


Transient Calibration
T-1 Target
T-2 Target
T-3 Target
Head (ft) NAVD88
Date


Sensitivity Analysis
100,000
10,000
1,000
Sum of Squared Residuals
Multiplier

Modflow Results



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Retiming Benefit

Block 1

(all values in feet)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Irrigation Recharge	0.000	0.000	0.003	0.023	0.103	0.141	0.185	0.145	0.081	0.027	0.000	0.000	0.707
Return Flow	0.060	0.054	0.060	0.058	0.060	0.058	0.060	0.060	0.058	0.060	0.058	0.060	0.707
Retiming Benefit	-0.060	-0.054	-0.057	-0.035	0.042	0.083	**0.124**	**0.085**	0.023	-0.033	-0.058	-0.060	0.000

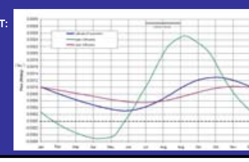
July and August "Evaporation Loss" Benefits of 0.066 and 0.052 feet, respectively.

Block 17

(all values in feet)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Irrigation Recharge	0.000	0.000	0.003	0.021	0.094	0.129	0.169	0.133	0.074	0.025	0.000	0.000	0.649
Return Flow	0.055	0.050	0.055	0.053	0.055	0.053	0.055	0.055	0.053	0.055	0.053	0.055	0.649
Retiming Benefit	-0.055	-0.050	-0.052	-0.033	0.039	0.076	**0.114**	**0.078**	0.021	-0.031	-0.053	-0.055	0.000

July and August "Evaporation Loss" Benefits of 0.070 and 0.055 feet, respectively.

GREENBELT:



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Other Study Areas

1. Horse Heaven Hills

(values in ft)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Irrigation Recharge	0.000	0.000	0.000	0.003	0.021	0.069	0.160	0.153	0.066	0.010	0.000	0.000	0.482
Return Flow	0.041	0.037	0.041	0.040	0.041	0.040	0.041	0.041	0.040	0.041	0.040	0.041	0.482
Retiming Benefit	-0.041	-0.037	-0.041	-0.036	-0.020	0.029	**0.119**	**0.112**	0.027	-0.031	-0.040	-0.041	0.000

2. Walla Walla Site

	Jan	Feb	Early Mar	Late Mar	Apr	May	Jun	Jul	Aug	Sep	Early Oct	Late Oct	Nov	Dec
Irrigation Recharge (cfs)	0.000	0.000	0.000	0.005	0.038	0.154	0.237	0.258	0.181	0.113	0.034	0.000	0.000	0.000
Return Flow (cfs)	0.081	0.081	0.081	0.082	0.083	0.084	0.085	0.086	0.086	0.086	0.085	0.085	0.084	0.082
Retiming Benefit (cfs)	-0.081	-0.081	-0.081	-0.077	-0.045	0.070	0.151	0.171	0.095	0.027	-0.052	-0.085	-0.084	-0.082

Note: values are in cfs based on conservation on actual 80-acre site.

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Context & Scale

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Conservation Benefit Summary

- Retiming Benefits Can Be Significant
  - Where Irrigation Source is Surface Water
  - If Conservation Applied to Multiple Sites
  - Less Significant for Groundwater Sources
- Reduced ET Loss Adds to Benefit
- Predictive Confidence Increased by:
  - Good Hydrogeologic Characterization
  - Uncertainty Analysis

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Conservation Benefit Summary

- Water Conservation will positively impact the river even if some of the saved water is used to irrigate additional acreage.
- IWM can be used to reduce river impacts real time and long term during the peak summer withdrawal periods.

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Where to From Here?

1. Private Water Right Holders vs. Irrigation District Users (regional conservation pools)
2. Source Water for the Odessa
3. Identify Other Geographic Areas Where this Will Work.

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Q & A

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