



Project Selection for In-Place Recycling and CRAB

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Types of Cold Recycling

- ▶ Cold Central Plant Recycling (CCPR)



- ▶ Cold In-Place Recycling (CIR)



Cold Central Plant Recycling

A viable alternative when stockpiles of high quality RAP are available or when it is not possible to in-place recycle the pavement. May be used immediately or stockpiled

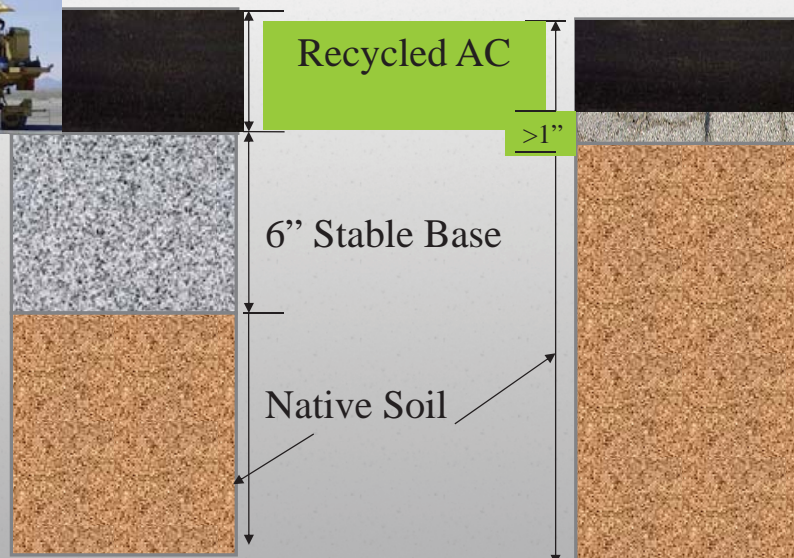


Cold In-Place Asphalt Recycling



Recycle AC to:

- Stable Base
- Within 1" of less Supportive Material



Multi-Unit CIR Train



Single Unit Trains



CR Recycling Agents & Additives

■ Recycling Agents

● Emulsified Asphalt

- Engineered Emulsions
- Polymer Modified Emulsions
- Solvent Free Emulsions (CSS-1) with Lime

● Foam (Expanded Asphalt)

■ Recycling Additives (added in small quantities)

- Cement
- Lime

ARRA Cold Planings

Full Depth Reclamation (FDR)



A rehabilitation technique in which the full flexible pavement section and a pre-determined portion of the underlying materials are uniformly crushed, pulverized or blended, resulting in a stabilized base course.



ARRA Cold Planings

Types of FDR

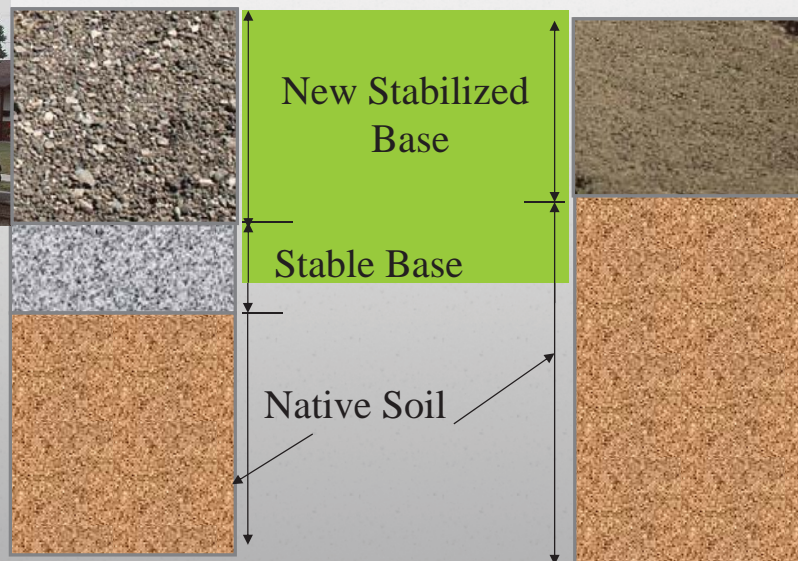
- **Mechanical Stabilization**
 - Pulverization
 - Corrective Aggregate/RAP
- **Bituminous Stabilization**
 - Foamed Asphalt
 - Emulsified Asphalt
- **Chemical Stabilization**
 - Cement/CKD (CRAB)
 - Lime/LKD
 - Self-Cementing Class C Fly Ash



Full Depth Reclamation (FDR)



Improves existing materials in-place to provide greater structural support and reduction of imported material.



Stabilizing Agent Selection Guide

Material Type – Including RAP	Well Graded Gravel	Poorly Graded Gravel	Silty Gravel	Clayey Gravel	Well Graded Sand	Poorly Graded Sand	Silty Sand	Clayey Sand	Silt, Silt with Sand	Lean Clay	Organic Silt/Organic Lean Clay	Elastic Silt	Fat Clay, Fat Clay with Sand
USCS ²	GW	GP	GM	GC	SW	SP	SM	SC	ML	CL	OL	MH	CH
AASHTO ³	A-1-a	A-1-a	A-1-b	A-1-b A-2-6	A-1-b	A-3 or A-1-b	A-2-4 or A-2-5	A-2-6 or A-2-7	A-4 or A-5	A-6	A-4	A-5 or A-7-5	A-7-6
Emulsified Asphalt SE > 30 or PI < 6 and P ₂₀₀ < 20%	X	X	X	X	X	X	X						
Foamed Asphalt PI < 10 and P ₂₀₀ 5 to 20%	X		X	X	X		X						
Cement, CKD or Self-Cementing Class C Fly Ash PI < 20 SO ₄ < 3000 ppm	X	X	X	X	X	X	X	X	X	X			
Lime/LKD PI > 20 and P ₂₀₀ > 25% SO ₄ < 3000 ppm								X		X		X	X

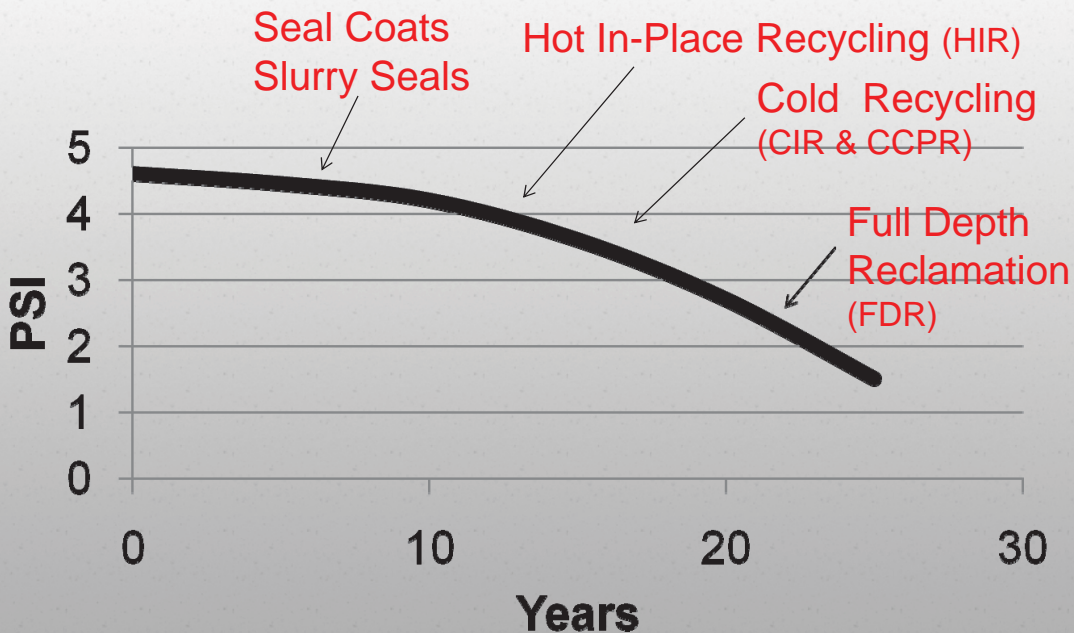
P₂₀₀ = Percent passing No. 200 (0.075 mm) sieve; SE = Sand equivalent (AASHTO T 176 or ASTM D2419); PI = Plasticity Index (AASHTO T 90 or ASTM D4318)

¹Additives may also be used in combination with a stabilizing agent to optimize performance of the FDR section

²USCS: Unified Soil Classification System, ASTM D2487

³AASHTO: American Association State Highway Transportation Officials, AASHTO M 145

Pavement Management



Where to Use In-Place Recycling

▶ CIR

- Where mill and fill is considered
- All cracking distresses provided not base related

▶ FDR/CRAB

- Where removal and replacement is considered
- All distresses provided not drainage related

▶ Logistics - Should accommodate equipment

Technique Selection

Attribute Description	Cold In-Place Recycling (CIR)	Full Depth Reclamation (FDR)
Attributes of Existing Pavement	Structurally sound, cracked, good profile	Requires structural improvement, distorted
Existing Pavement Depth	> 4" (100 mm)	
Typical Materials Reclaimed	100 % RAP	Any combination of RAP and Underlying Materials
Typical Treatment Depth	3-5" (75-125 mm)	4-12" (100 - 300 mm)
Typical Cross Sections Treated	Urban, Rural, Freeway	

Technique Selection

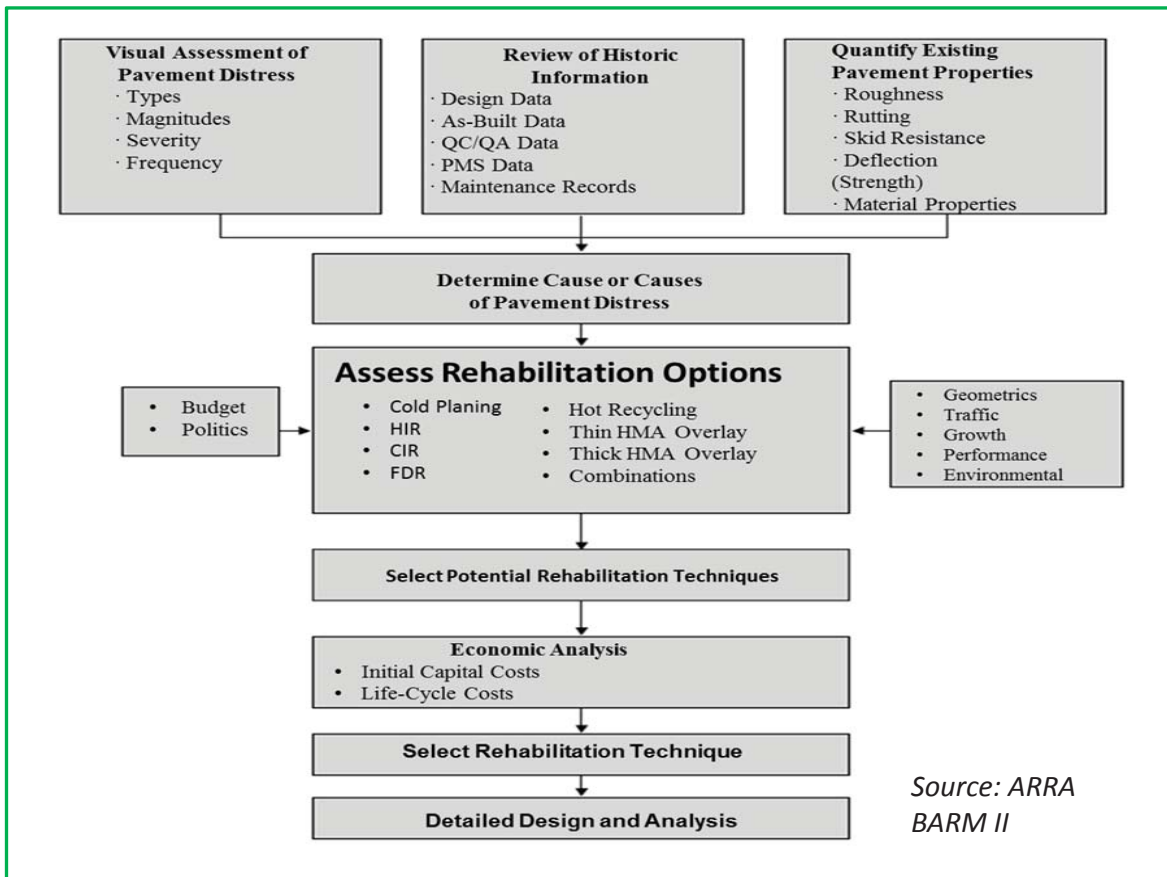
Attribute Description	Cold In-Place Recycling (CIR)	Full Depth Reclamation (FDR)
Traffic	Capable of Treating Full Range of Traffic	
Potential Geometric Limitations	Tight turns, steep grades, profile correction	None
Typical Overlay Treatment	Hot Mix Asphalt, Chip Seals, Slurry Surfacing, Fog seal	Hot Mix Asphalt, Chip Seals
Performance Measures	Removal of surface distresses, helps mitigate reflective cracking, improves smoothness and profile	Eliminates pavement distresses, increases structural capacity, & restores profile

Keys to a Successful/Quality Recycling Project

- ▶ **Proper Site Selection – Right Method
Right Road – Right Time**
- ▶ **Good Communication and Education**
- ▶ **Experienced Contractor**
- ▶ **Quality Achieved**
 - **Before Design**
 - **Before Construction**
 - **During Construction**



QUALITY PHASE 1 BEFORE DESIGN (PROJECT SELECTION)



Recycling & Reclaiming Strategies

M&R	Strategy	Method	CP	HIR	CR	FDR
Construction	New					
	Reconstruction		X			X
Rehabilitation	Major		X		X*	X
	Structural Overlay		X	X*	X*	X*
Maintenance	Minor	PP	X	X	X	
	Preventative		X	X	X	
	Routine		X			
	Corrective		X	X	X	
	Catastrophic		X			

*With HMA Overlay

PP = Pavement Preservation

Pavement Conditions that Can be Addressed by Cold In-Place Recycling

Ruts	< 3/4 in	✓	Ride - Poor	✓
	> 3/4	? ¹	Poor Drainage	no
Crack	Fatigue	? ¹	Snow Plow Use	✓
	Longitudinal	✓	Low Skid Resistance	✓
	Transverse	✓	Asphalt Crumb Rubber	no
	Block	✓	Stripping Pavement	? ²
Surface	Dry	✓	Paving Fabrics	? ³
	Flushing	✓	Structural Deficiency	no
	Bleeding	✓	Base Failure	no
	Variable	✓		
Raveling		✓	Questions?	
Potholes		✓	1. Provided not base, subgrade or unstable mix related.	
Texture - Rough		✓	2. Depends on severity. May be able to add antistripping additive.	
		✓	3. No problem if properly installed. If not, logistical issue with additional costs for disposal.	

Pavement distresses which can be corrected by FDR include

- ▶ All forms of cracking including age, fatigue, edge, slippage, block, longitudinal and reflective
- ▶ Reduced ride quality due to swells, bumps, sags, patches and depressions
- ▶ Permanent deformations including rutting, corrugations and shoving
- ▶ Loss of bond between pavement layers
- ▶ Moisture damage (stripping)
- ▶ Loss of surface integrity due to raveling, potholes and bleeding
- ▶ Excessive shoulder drop off
- ▶ Inadequate structural capacity
- ▶ Subgrade instability

Pavements Not to be In-place Recycled



Paving fabric makes it tough!

- Possible but messy for CIR & FDR



CIR will not fix base problems!

Quality Phase 2 Before Construction



Engineered Approach



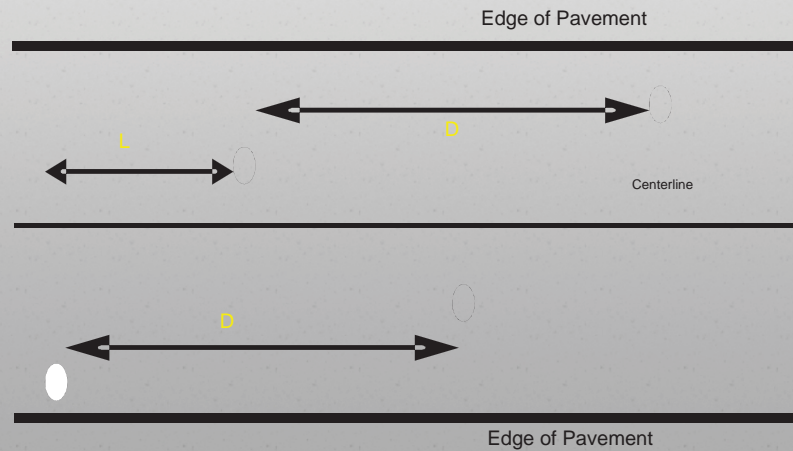
- ▶ **Sampling of In-place Materials**
 - Coring For Thickness
 - Ground Penetrating Radar
- ▶ **Variable thickness causes issues with**
 - Recycling/stabilizing agent application rates
 - Support of recycling train

Coring – For Depth & Use In Mix Design



Obtain cores from edge, wheel paths, near centerline and in shoulders if shoulders will be recycled

Cores in Lab cut to planned recycling depth and only that portion to be recycled used for mix design



DCP

DCP	Acceptable	Marginal	Poor
Each Set of 10 Blows	< 6 Inches <150 mm	6 to 10 inches 150 mm to 250 mm	> 10 Inches > 250 mm
Inches per Blow	0.6	0.6 to 1.0	> 1.0
mm per Blow	15	15 to 25	> 25



Addresses Subgrade:

To Support Train

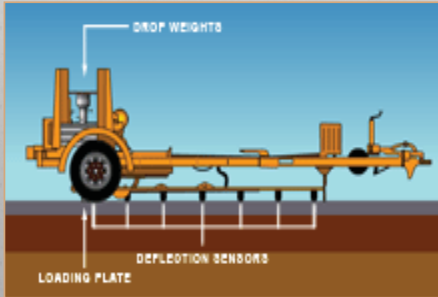
To Support Temporary Traffic



Pavement Analysis Guide – Structural Assessment



- ▶ Falling Weight Deflectometer (FWD)
- ▶ Light Weight Deflectometer (LWD)



Pavement Analysis Guide – Design

- ▶ Utilize pavement design guides/software
 - 1993 AASHTO
 - MEPDG?
- ▶ Common layer coefficients utilized

Treatment	Structural Number	VDOT I-81 Study
CIR/CCPR	0.30-0.35	0.39
CRAB	0.15-0.25	
FDR	0.20-0.30	

Mix Design Determines:

- ▶ **Optimum Recycling/Stabilizing Agent Rate**
- ▶ **Requirement for and dosage rate of additives (corrective aggregate, hydrated lime or cement)**
- ▶ **Required mix characteristics such as indirect tensile strength, Marshall stability, retained stability, raveling, compressive strength, etc.**



Environmental Conditions



**Decreased Service Life -
Adequate strength is not achieved
if curing is incomplete**

- ▶ **CIR & FDR should not performed during excessively wet conditions, nor started if rain is imminent**
- ▶ **Minimum ambient and RAP temp. of 50°F for CIR**
- ▶ **Overnight ambient temperature above 35°F**
- ▶ **No Freezing weather expected within 7 days of end of CRAB placement**

Mixture

**Decreased Service Life -
Non-homogeneous mixture;
incorporation of deleterious
materials; wrong application
rate of recycling/stabilizing
agent, water or any additives**



- **Calibrate mixing system to ensure that the recycling agent, water and additives are added at the proper rates specified in mix design**
 - **Beginning of each season with full material calibration**
 - **Every lot during project by in-place volumetrics**
 - **End of each day by volumetrics and certified delivery weight tickets**

Check Spread Rate of Cement using Canvas Patch Test



Sample Each Tanker of Recycling Agent Prior to Use

Foamed Asphalt

Half Life and Expansion Ratio



Emulsified Asphalt

Visual Sieve Test



Compaction

Decreased Service Life – Inadequate compaction leads to lack of stability and cohesion. Secondary compaction from traffic caused by insufficient rolling



- ▶ For CIR & FDR use test strip to establish rolling pattern and target density
- ▶ For CRAB typically use AASHTO T 134 or ASTM D558
- ▶ Test In-place density with nuclear gauge at random locations
 - Once per ¼ mile (200 m)
- ▶ Verify rollers have working water to prevent pickup and raveling

Curing and Protection

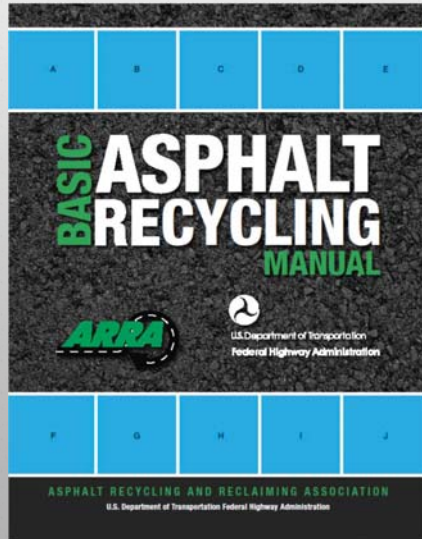
Decreased Service Life – Insufficient curing leads to lack of cohesion for CIR and FDR and low strength/cracking issues with CRAB. Raveling during curing is the most common distress of CIR.



- ▶ Fog seal at the end of shift to minimize raveling during curing
- ▶ Moist cure or use curing membrane for CRAB
- ▶ Apply sand blotter to avoid pickup of fog seal
- ▶ Allow to cure prior to surface course

Basic Asphalt Recycling Manual

2nd Edition



► Sent to Publisher

- Preconstruction Activities
- Mix Design
- Construction
- QC Sampling & Testing
- Available Soon

Education Resources

- Pavement Preservation Application Checklist Series
- Updated HIR & CIR, New FDR
- www.pavementpreservation.org
- www.arra.org & www.fhwa.gov



Training Resources

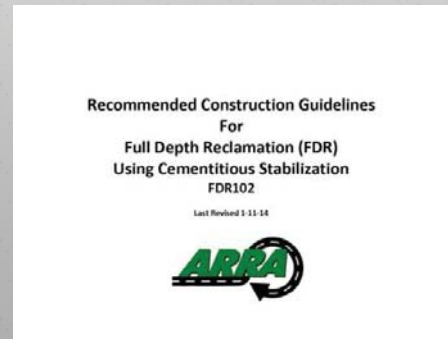
- ▶ ***TCCC Inspector Training for Cold In-Place Recycling (CIR) Web Based***
FHWA-NHI-134114
- ▶ **Currently Under Development**
 - **TC3 Inspector Training for HIR.**
Anticipated availability December 2014
 - **TC3 Inspector Training for FDR.**
Anticipated availability May 2015

Training Resources

- ▶ **http://www.nhi.fhwa.dot.gov/training/course_search.aspx?tab=0&key=colId&typ=3&sf=0&course_no=134114**
- ▶ **www.tccc.gov**
- ▶ **Link on www.arra.org**
- ▶ **ARRA has 1-day General and Training Seminars**

ARRA Best Practice Recycling Guidelines

- ▶ It is not intended or recommended that these guidelines be used verbatim within a specification. Owner agencies should use them to help establish their particular project specification.



ARRA Guidelines

- ▶ 100 Series - Recommended Construction Guidelines
- ▶ 200 Series - Recommended Mix Design Guidelines
- ▶ 300 Series - Recommended Quality Control Sampling and Testing Guidelines
- ▶ 400 Series – Recommended Project Selection Guidelines

Status of ARRA Guidelines



Series	Cold Planing		Cold Recycling	
	Milling	Micro Milling	CIR	CCPR
100 Series Construction	Final Review	Final Review	Complete	Under Development
200 Series Mix Design	N/A	N/A	Complete*	
300 Series QC	Under Development		Complete	
400 Series Project Selection	N/A	N/A	Under Development	

Status of ARRA Guidelines



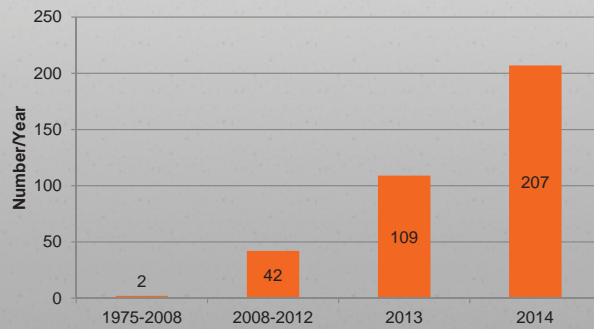
Series	Full Depth Reclamation (FDR)		
	Bituminous	Cementitious	Lime
100 Series Construction	Complete	Complete	Complete
200 Series Mix Design	Under Development		
300 Series QC	Under Development		
400 Series Project Selection	Under Development		

Thank You

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Magnitude 3.0 Earthquakes



ARRA Cold Planning