Grade-Separated Trail Crossings

How Do We Get Over There?

2008 National Trails Symposium

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PRESENTATION OVERVIEW

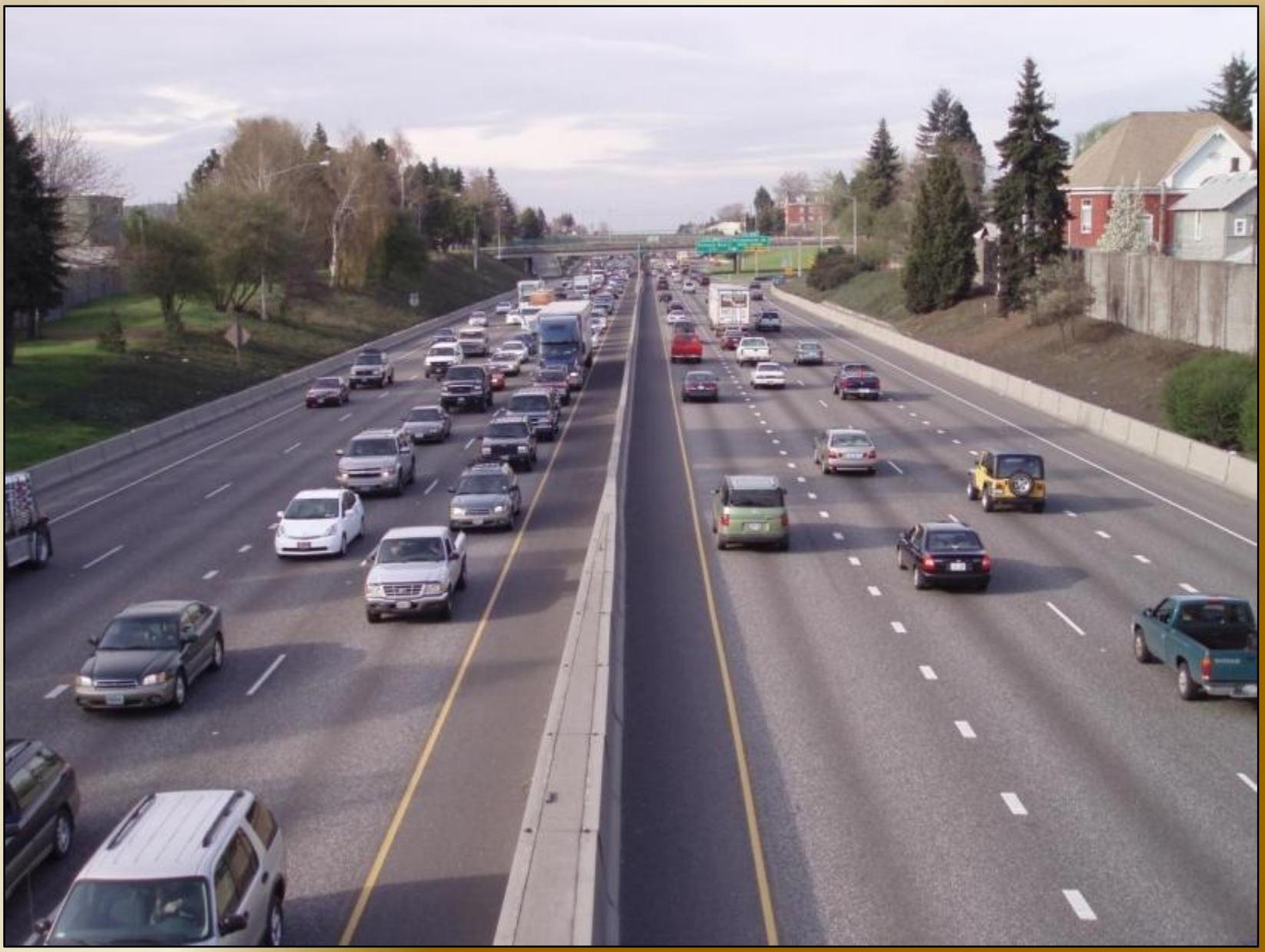
- ✓ Why grade-separated crossings?
- ✓ What barriers are we trying to cross?
- ✓ Decision-making process
- ✓ At-grade or grad-separated? Go over or under? Where to build it? Etc.
- ✓ Pedestrian underpass design considerations
- ✓ Bridge/overpass design considerations

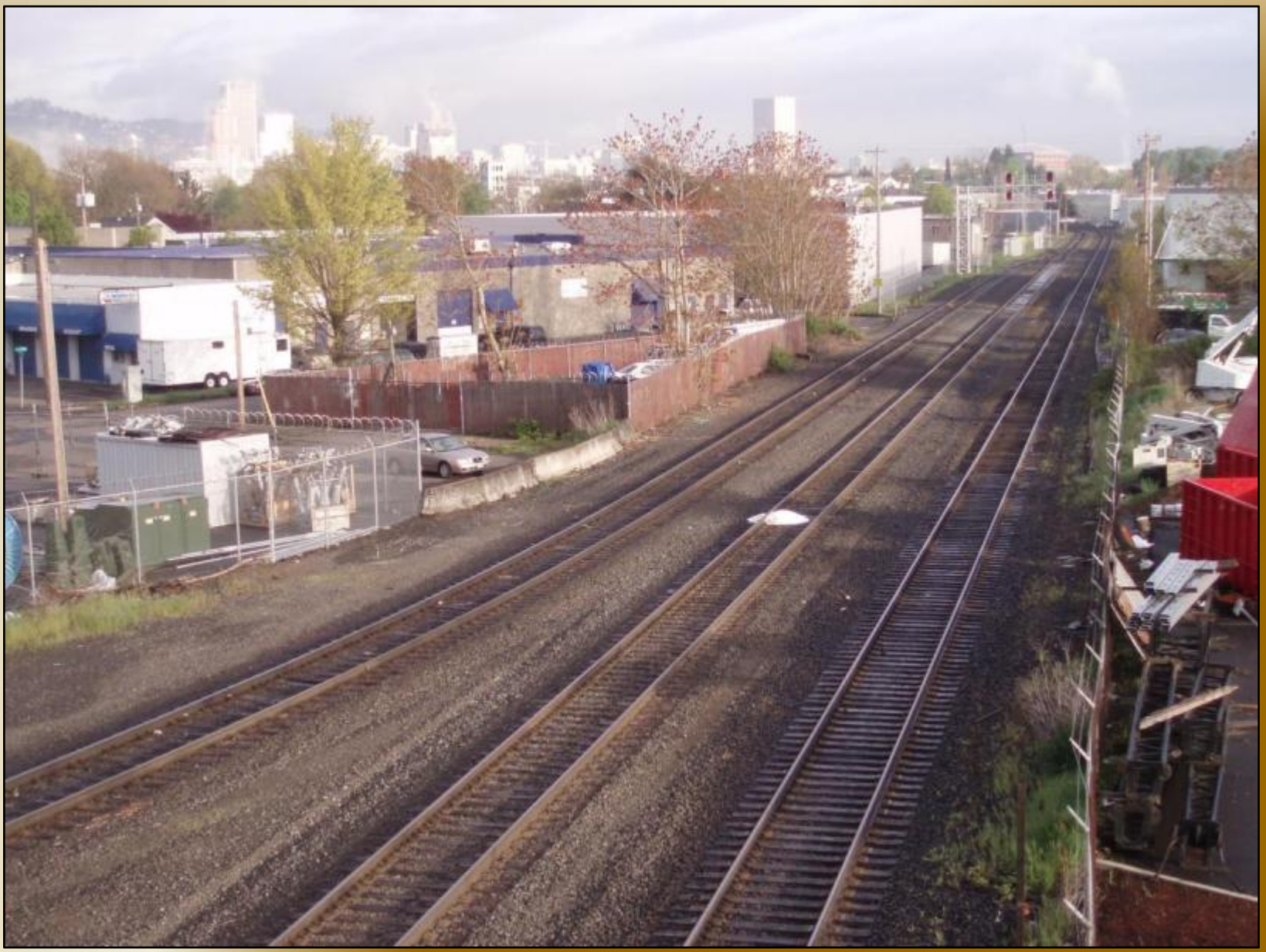
WHY GRADE-SEPARATED CROSSINGS?

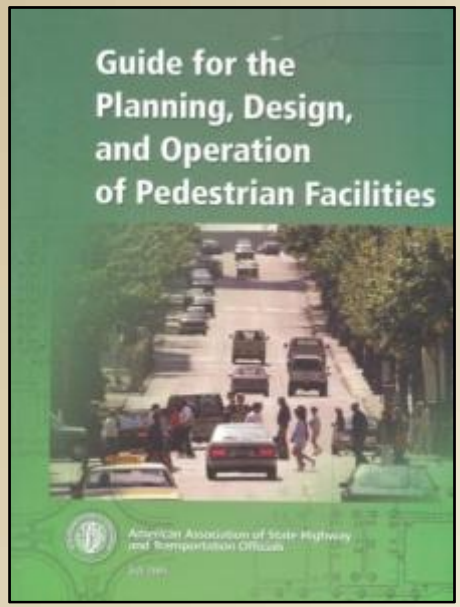
- ✓ **Critical links in the bike/ped network: overcome barriers**
- ✓ **Provide bike/ped links where at-grade crossings are not possible**
- ✓ **Respond to a demand for safe crossings where they didn't previously exist**
- ✓ **Provide direct links where the surrounding transportation system offers limited connectivity**
- ✓ **More than just a transportation facility**

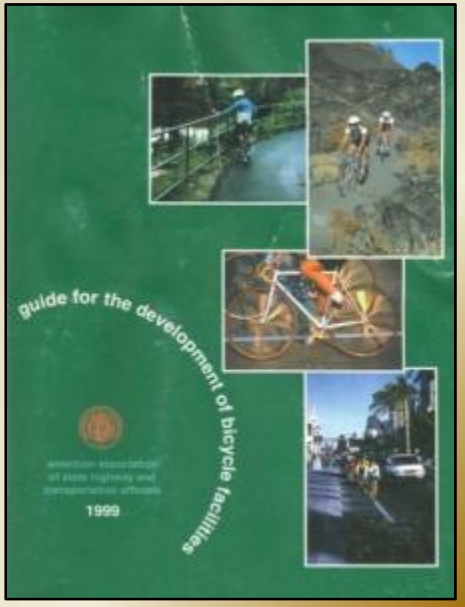
What are the barriers?

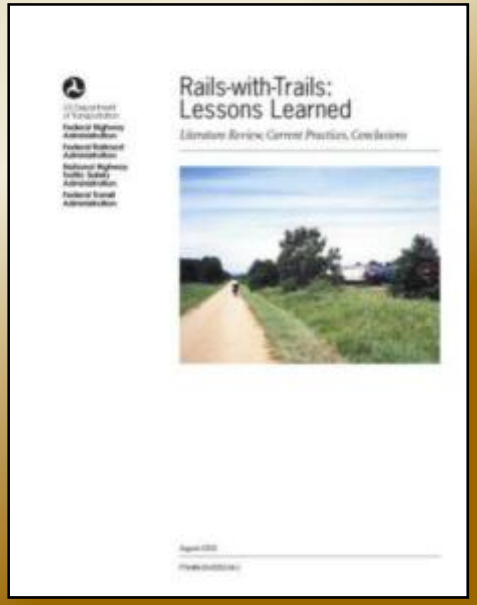
What are we trying to cross?

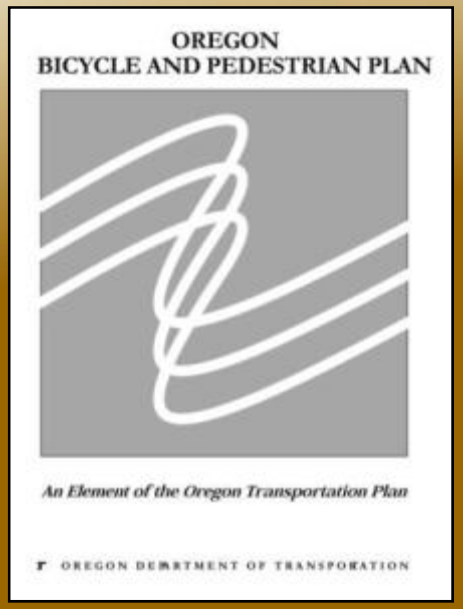





Guide for the Planning, Design, and Operation of Pedestrian Facilities
American Association of State Highway and Transportation Officials


guide for the development of bicycle facilities
1999


Rails-with-Trails:
Lessons Learned


OREGON
BICYCLE AND PEDESTRIAN PLAN
An Element of the Oregon Transportation Plan
OREGON DEPARTMENT OF TRANSPORTATION


Design
Manual
M 22-01
Washington State Department of Transportation


PEDESTRIAN FACILITIES
GUIDEBOOK
Incorporating Pedestrians Into
Washington's Transportation System
Sponsored by
Prepared by
September 1997


Improving the
Pedestrian
Environment
Through
Innovative
Transportation
Design
Prepared by
ite
Institute of Transportation Engineers

HOW DO WE GET OVER THERE?

The decision-making process

- ✓ At-grade or grade-separated?
- ✓ Go over or go under?
- ✓ Where do we build it?
- ✓ What kind of access can/do we provide?
- ✓ What are the details?
- ✓ Can we afford it?

DECISION-MAKING PROCESS

Question 1:

At-grade or grade-separated?

- ✓ **Largely depends on the barrier being crossed**

WATERWAYS

FREEWAYS

RAILROADS

MAJOR ROADS

DECISION-MAKING PROCESS

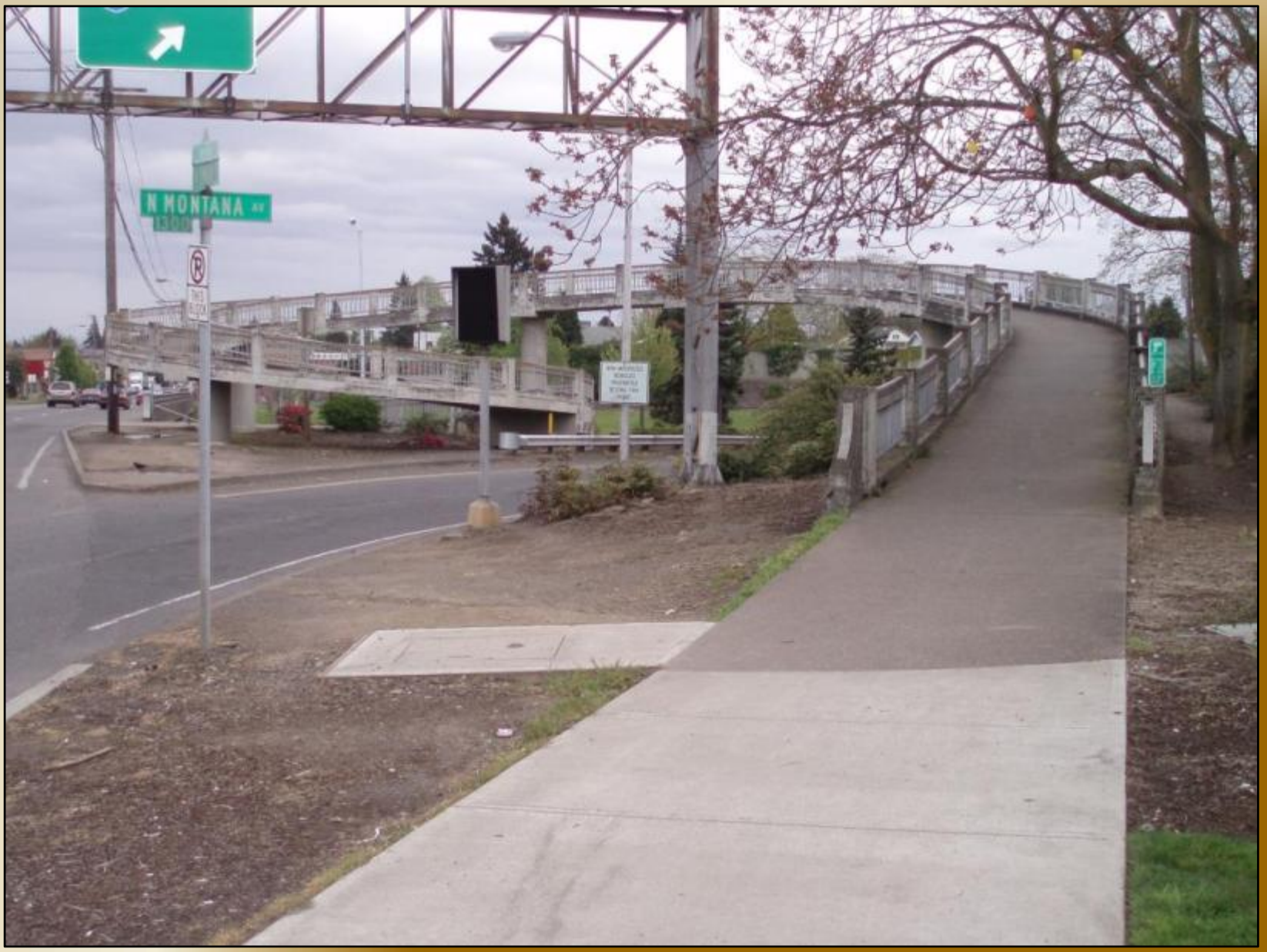
- ✓ **The main dilemma: Getting across major roads (and to some extent, railroads)**

USING A BRIDGE/TUNNEL VS. CROSSING AT-GRADE

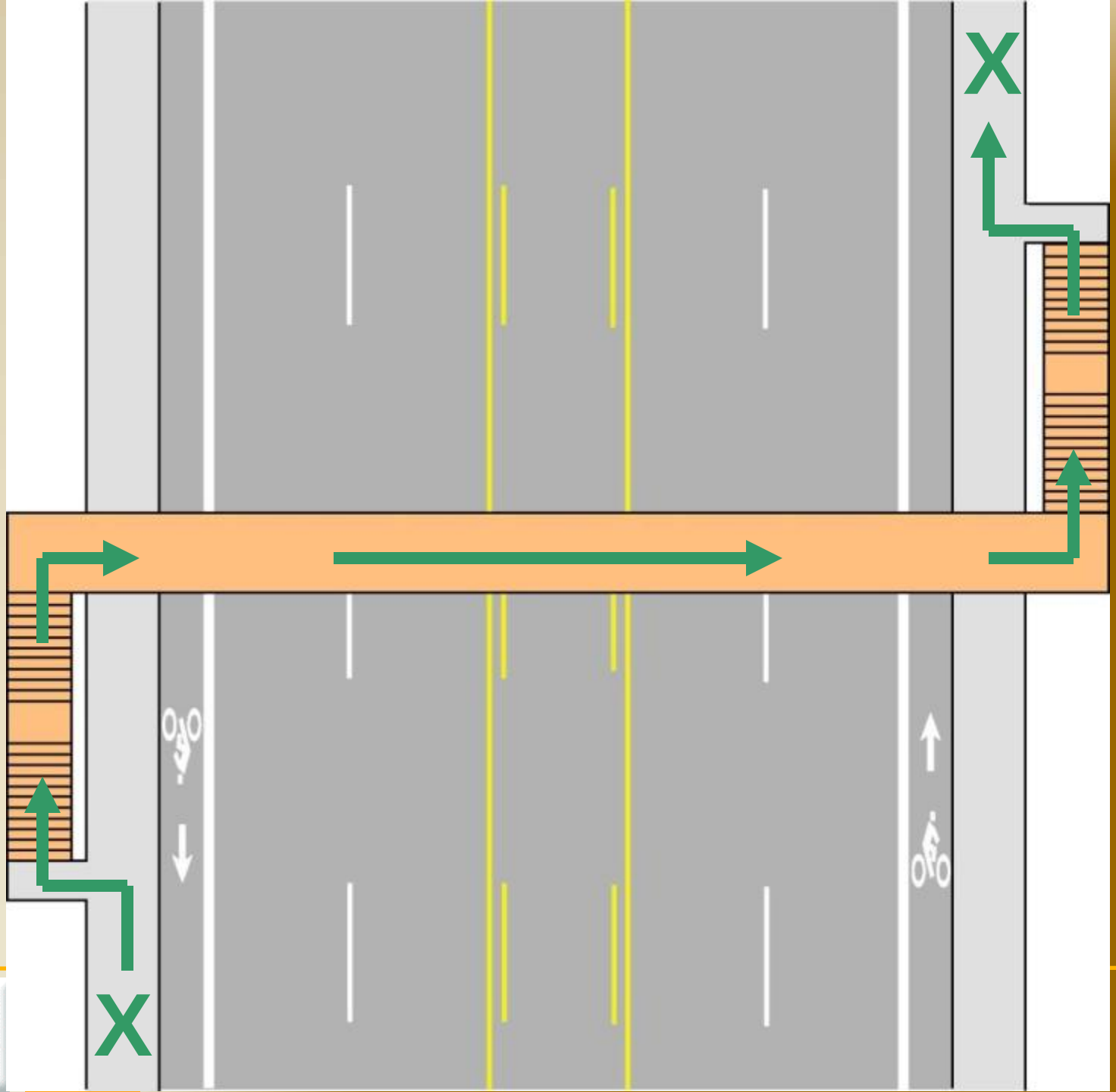
- ✓ **User's decision based on:**
  - **Bridge/tunnel location relative to desired travel route**
  - **Availability of alternative crossings**
  - **Elements precluding/discouraging at-grade crossings**
  - **Perceived risk of crossing at-grade**
  - **Distance/time needed to access and cross the bridge/tunnel**

USING A BRIDGE/TUNNEL VS. CROSSING AT-GRADE

- ✓ **Institute of Transportation Engineers Study (1998):**
  - **70% of peds would use a bridge/tunnel if travel time = at-grade crossing time**
  - **If If bridge/tunnel travel time >50% of at-grade crossing time: Very low use**
- ✓ **Washington State DOT Design Manual:**
  - **Low bridge/tunnel use if walking distance for 85% of peds is ¼-mile of at-grade crossing distance**


N MONTANA


TRIMET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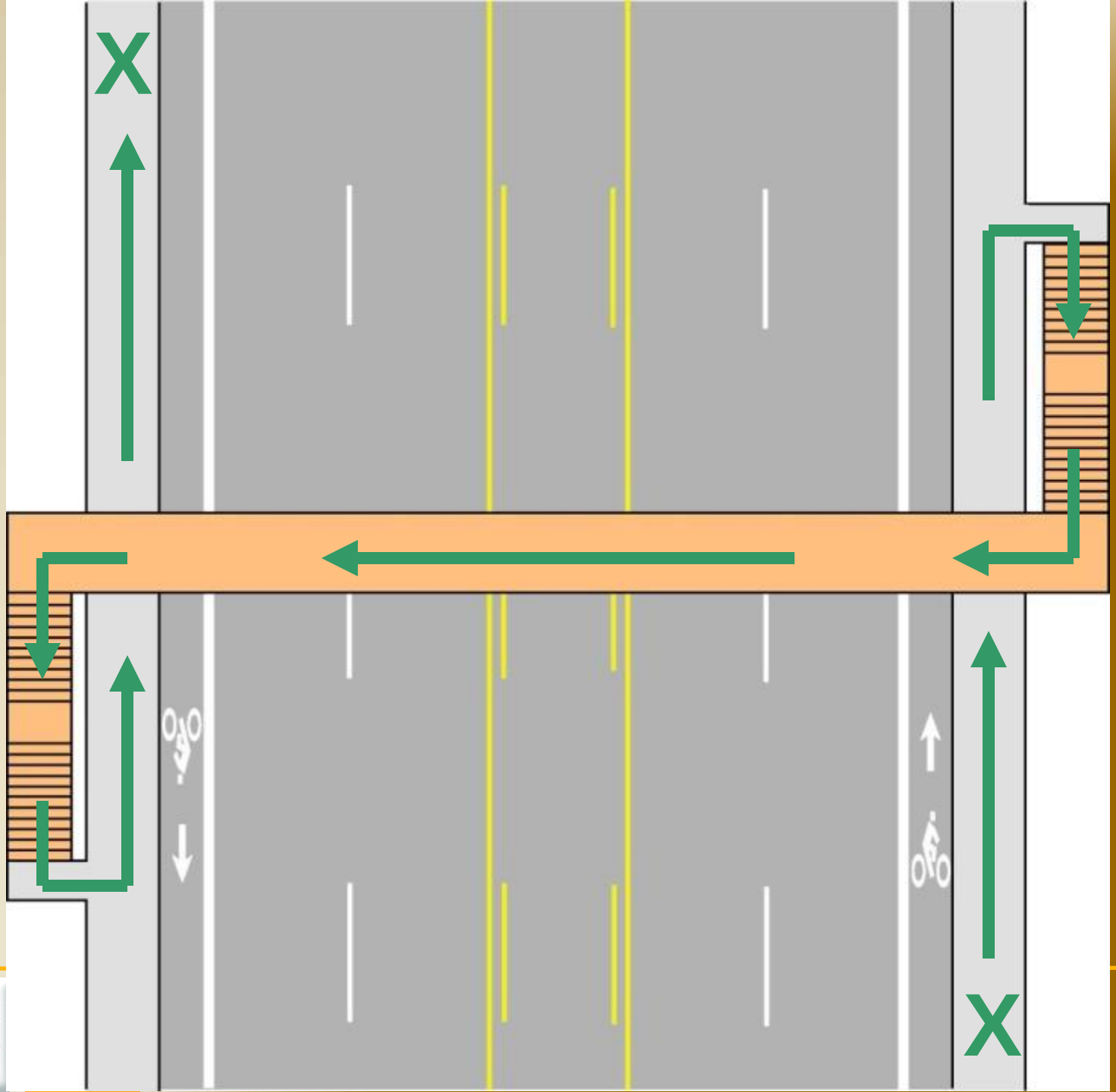
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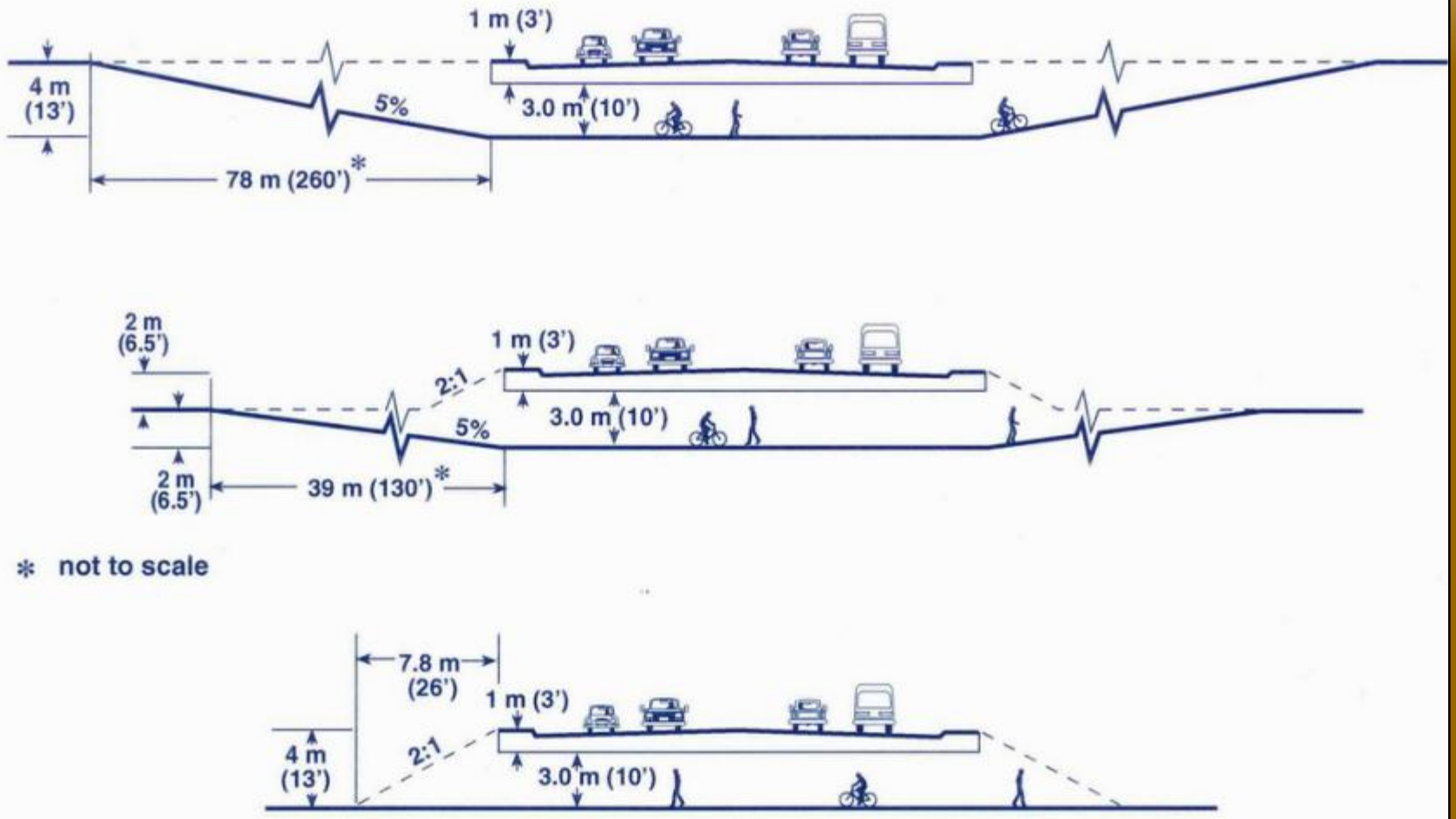
X

DECISION-MAKING PROCESS

Question 2:

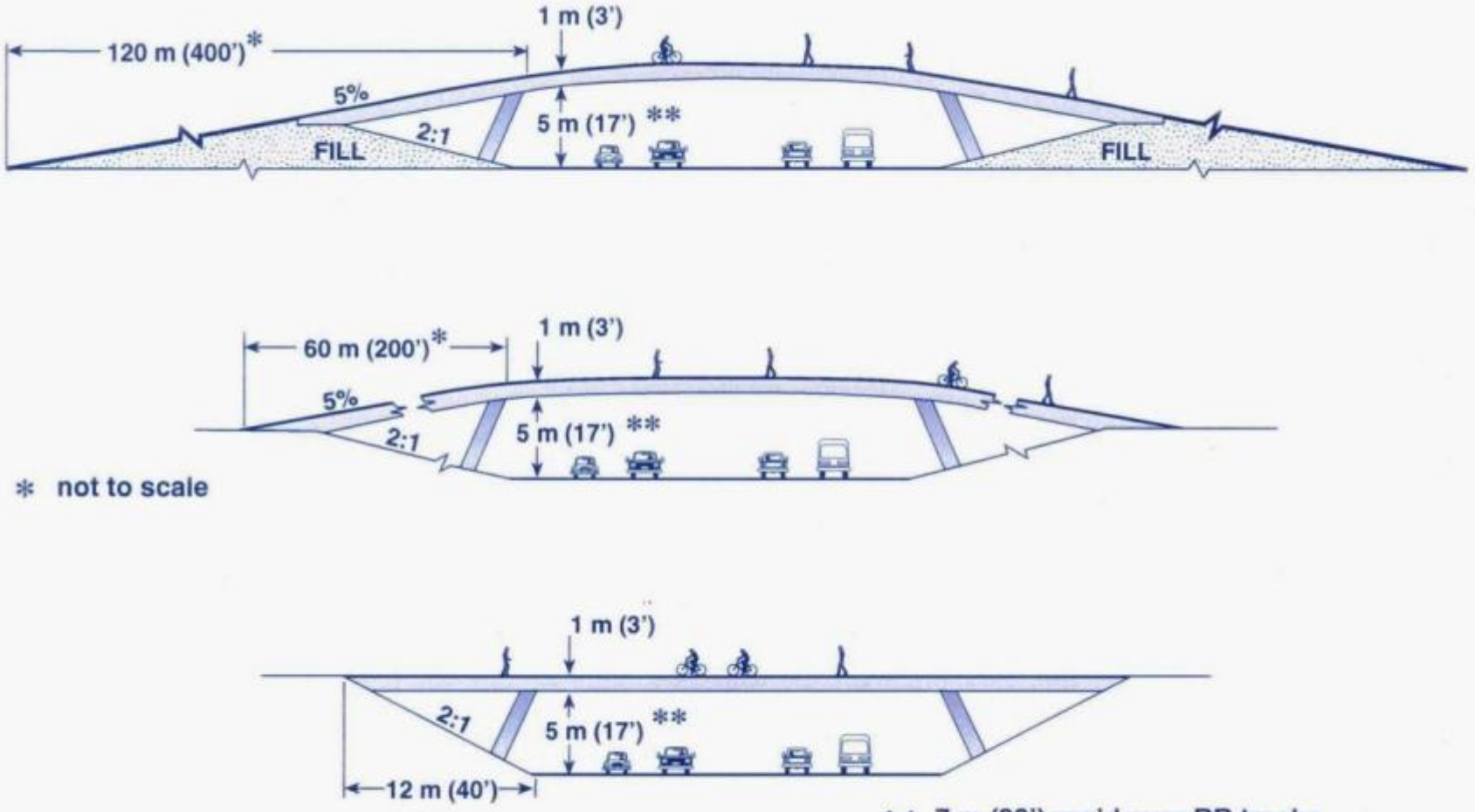
Go over or go under?

- ✓ **Drainage, environmental impacts, adjacent property impacts, constructability, user safety and security, etc.**
- ✓ **Vertical ascent/descent necessary to reach bridge/tunnel**



Source: Oregon Bicycle and Pedestrian Plan

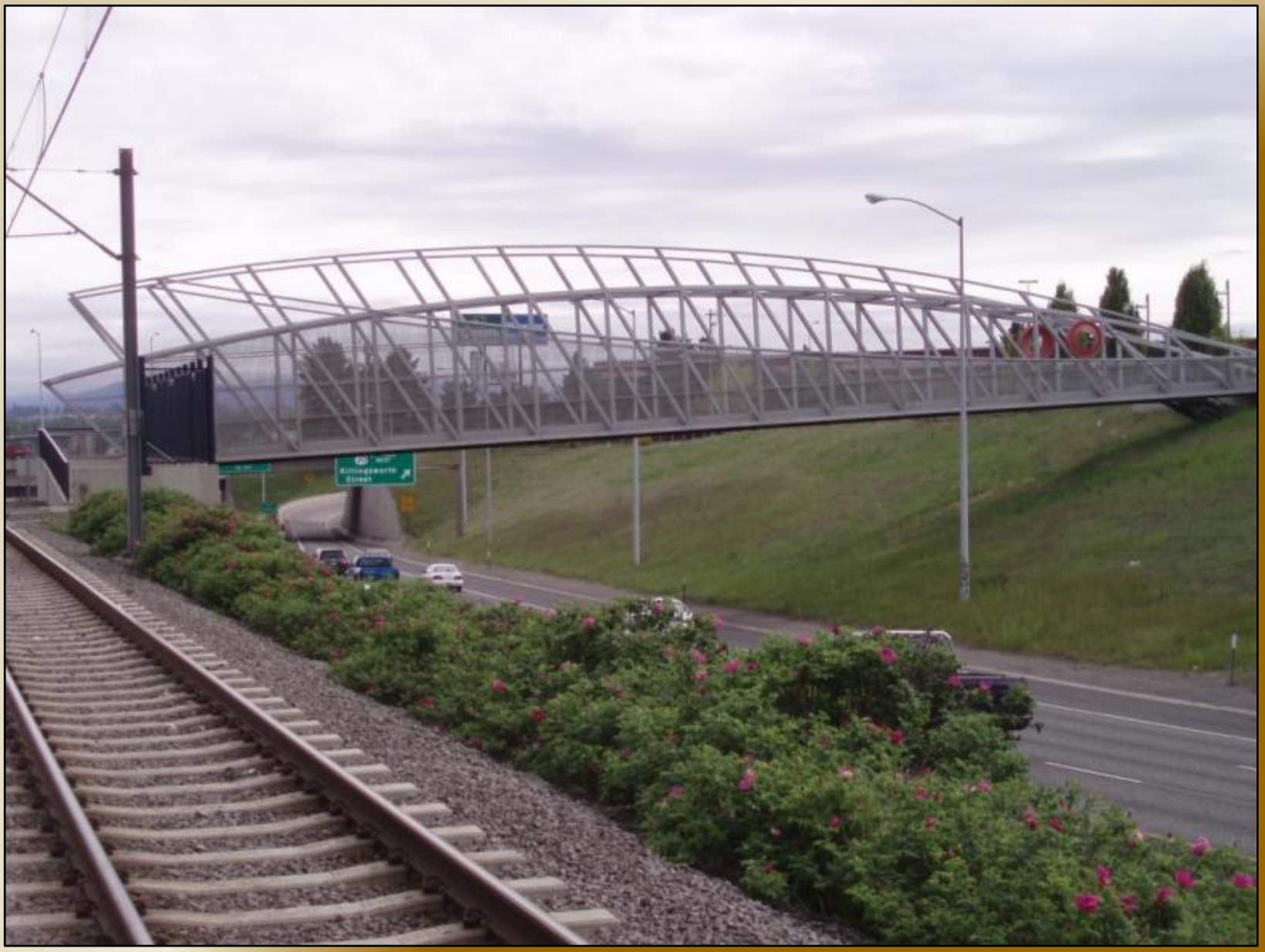

KEEP
RIGHT



* not to scale

** 7 m (23') req'd over RR tracks

Source: Oregon Bicycle and Pedestrian Plan



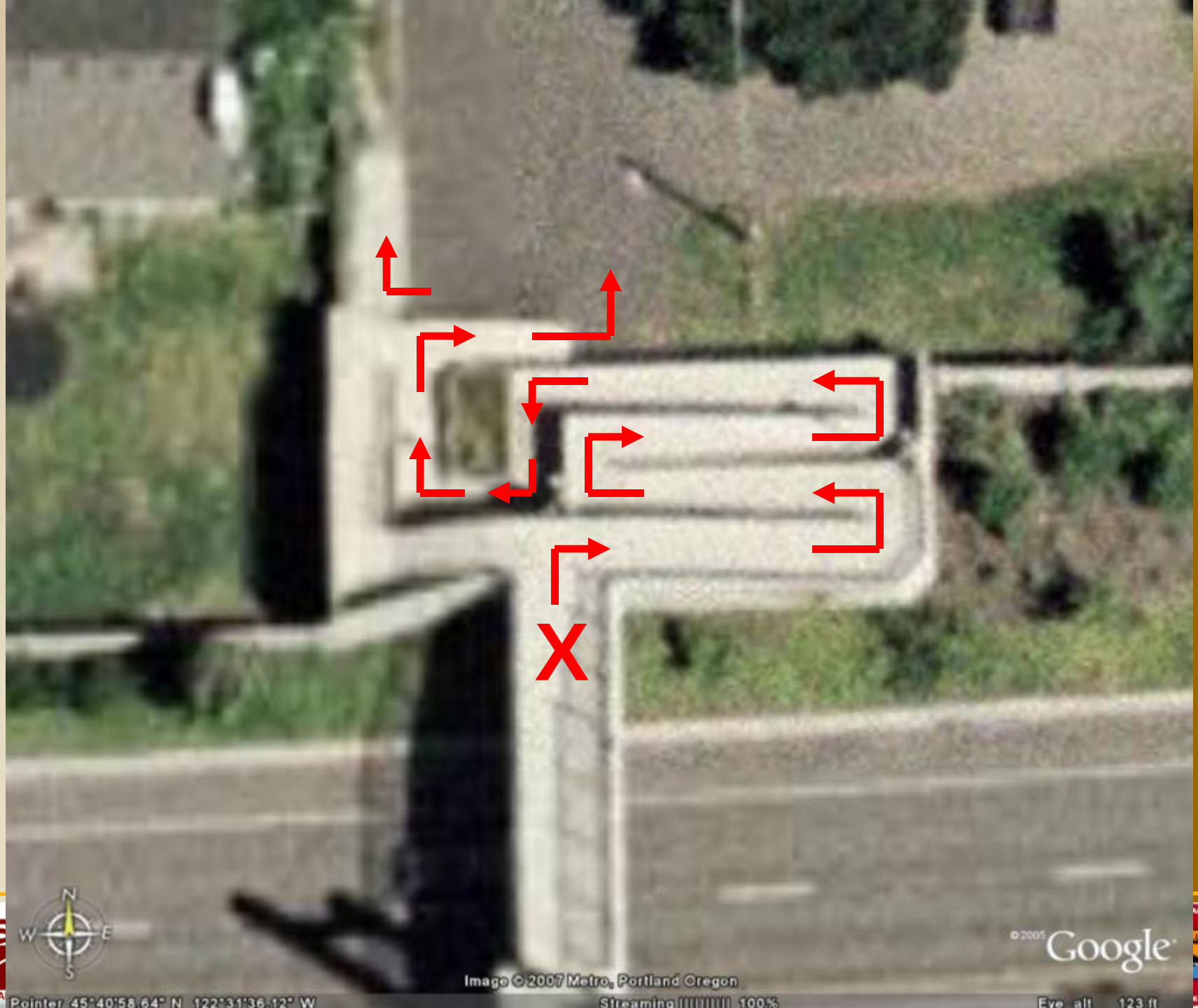

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Image © 2007 Metro, Portland Oregon
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DECISION-MAKING PROCESS

Question 3:

Where do we build it?

- ✓ **Bridge/tunnel proximity to:**
  - **Surrounding pedestrian/bicycle facilities**
  - **Logical walking/bicycling routes and destinations**
  - **Alternative crossing opportunities**

DECISION-MAKING PROCESS

- ✓ **Surrounding pedestrian/bicycle facilities**
  - **Good connections to surrounding facilities highly important**
  - **Bridges/tunnels within an overall comprehensive network = potentially higher usage**
  - **Wayfinding critical**


Parkcrest
Summer


Ramp Located
East of Stairs


HIGHWAY 3 PEDESTRIAN
OVERPASS TO WESTPARK


PDC
PORTLAND
TRANSPORTATION
N FAILING STREET
OVERCROSSING


SWTrails
5


DOWNTOWN
SELLWOOD
Yield to Pedestrians
Reduce Speed
Pass Left
Keep Right

DECISION-MAKING PROCESS

- ✓ **Logical walking/bicycling routes; Proximity to destinations**
  - **Should not require out-of-direction travel to/from a logical travel route or desired destination**


Alternate crossing
Bridge
Primary walk/bike route
© 2008 Tele Atlas
Google
Pointer 45°30'04.97" N 122°39'19.75" W
Streaming 100%
Eye alt 989 ft

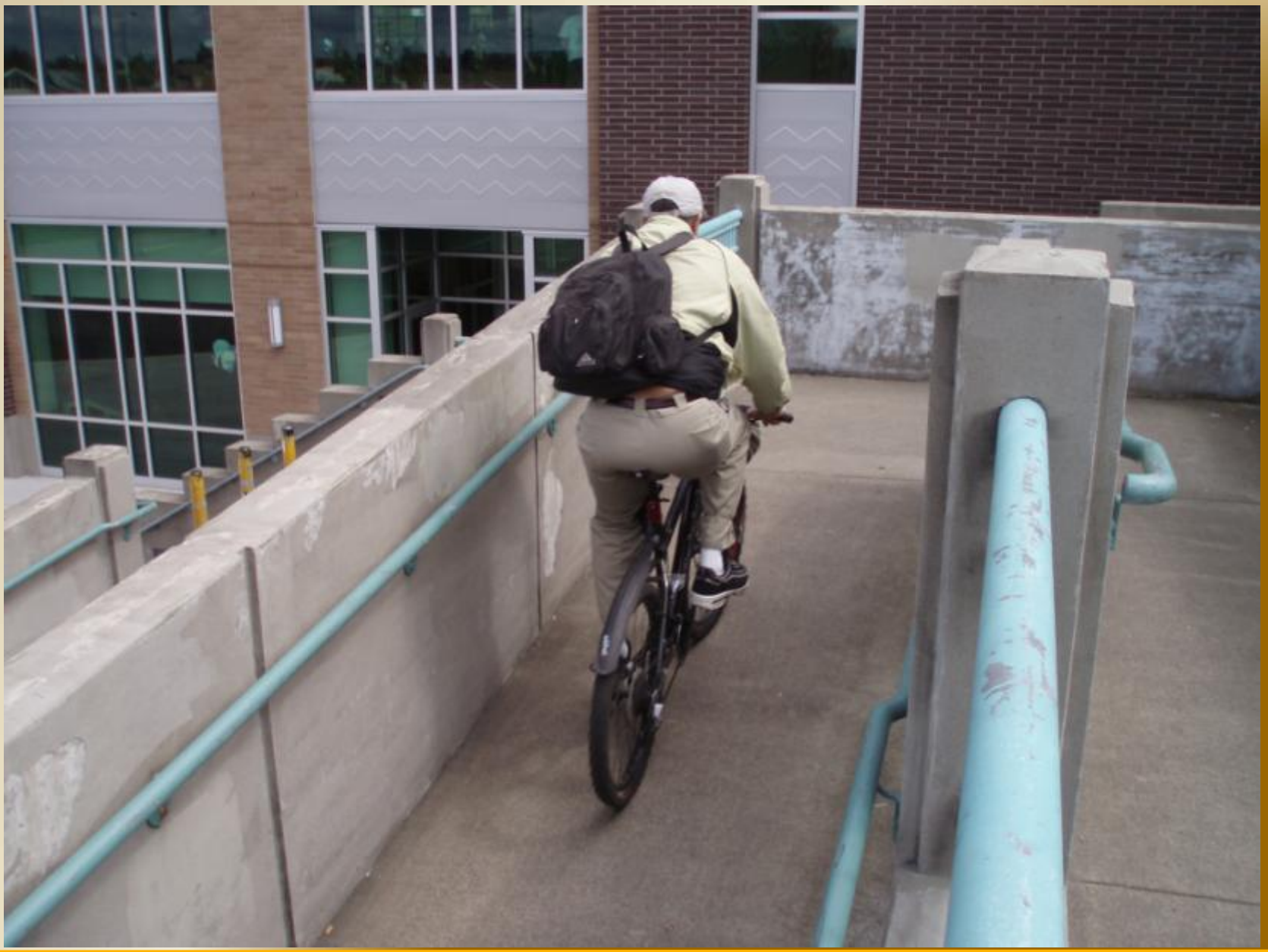
DECISION-MAKING PROCESS

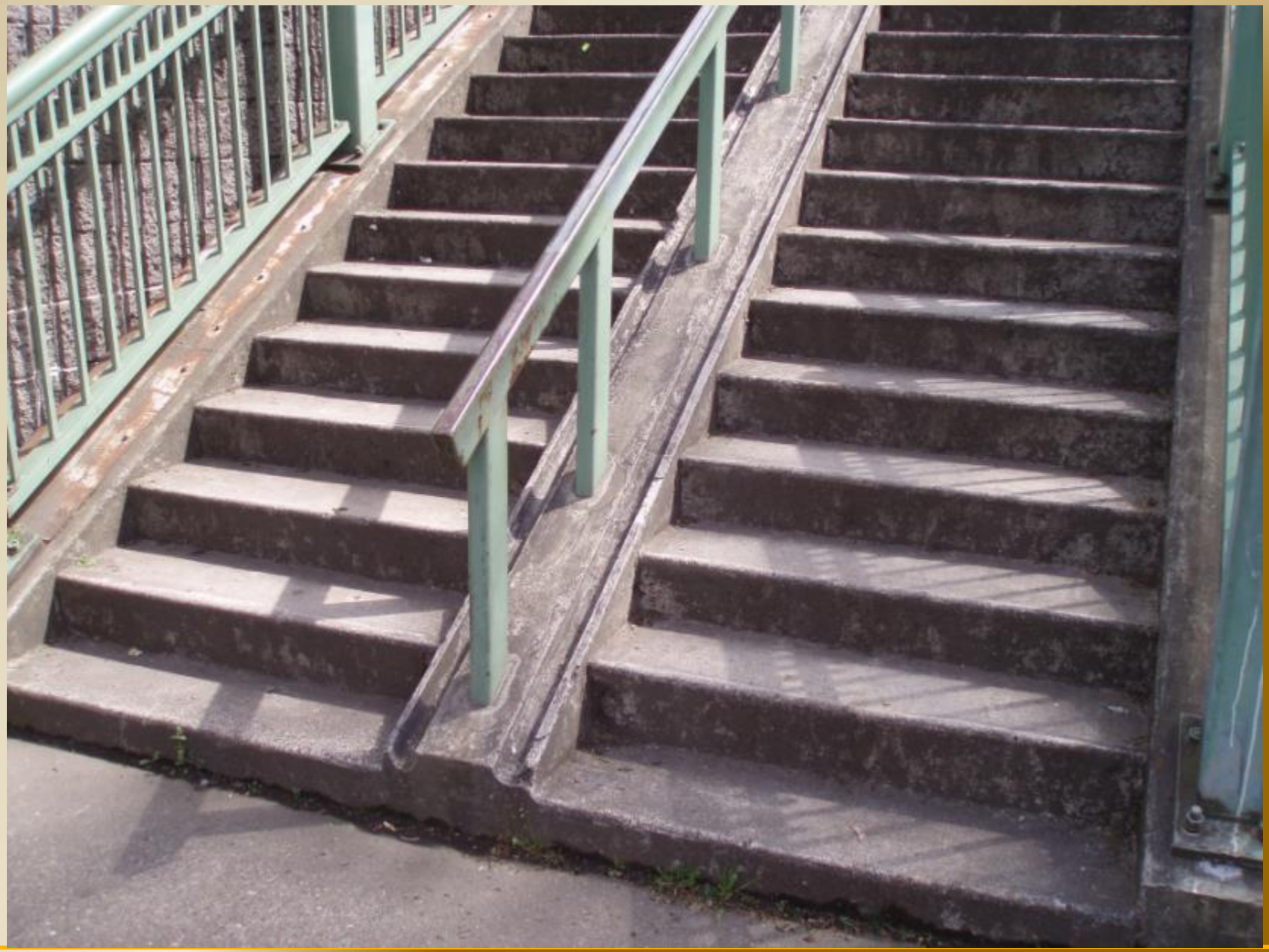
Question 4:

What kind of access can/do we provide?

- ✓ **Depends on:**
  - **Amount of necessary vertical ascent/descent**
  - **Available “footprint” space**


STOP





DECISION-MAKING PROCESS

- ✓ **Bridges/tunnels serving multiple functions**
  - **Visual icons**
  - **Enhance user experience**
  - **Bridges as community gathering places**
  - **Tourism**

DECISION-MAKING PROCESS

Question 5:

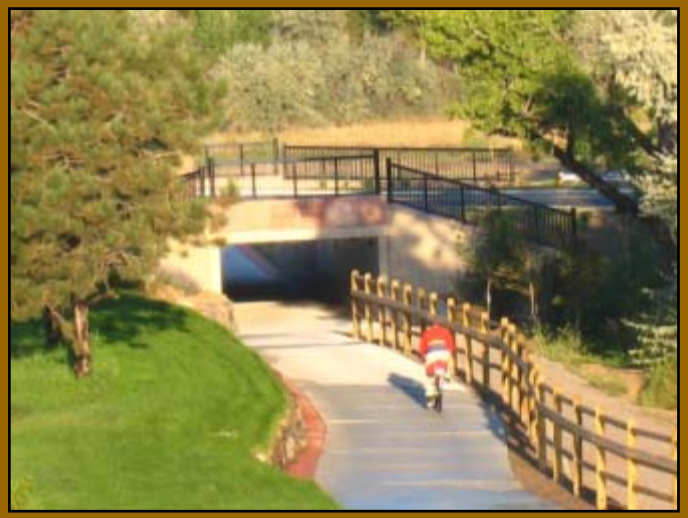
What are the details?

- ✓ Pedestrian Underpass

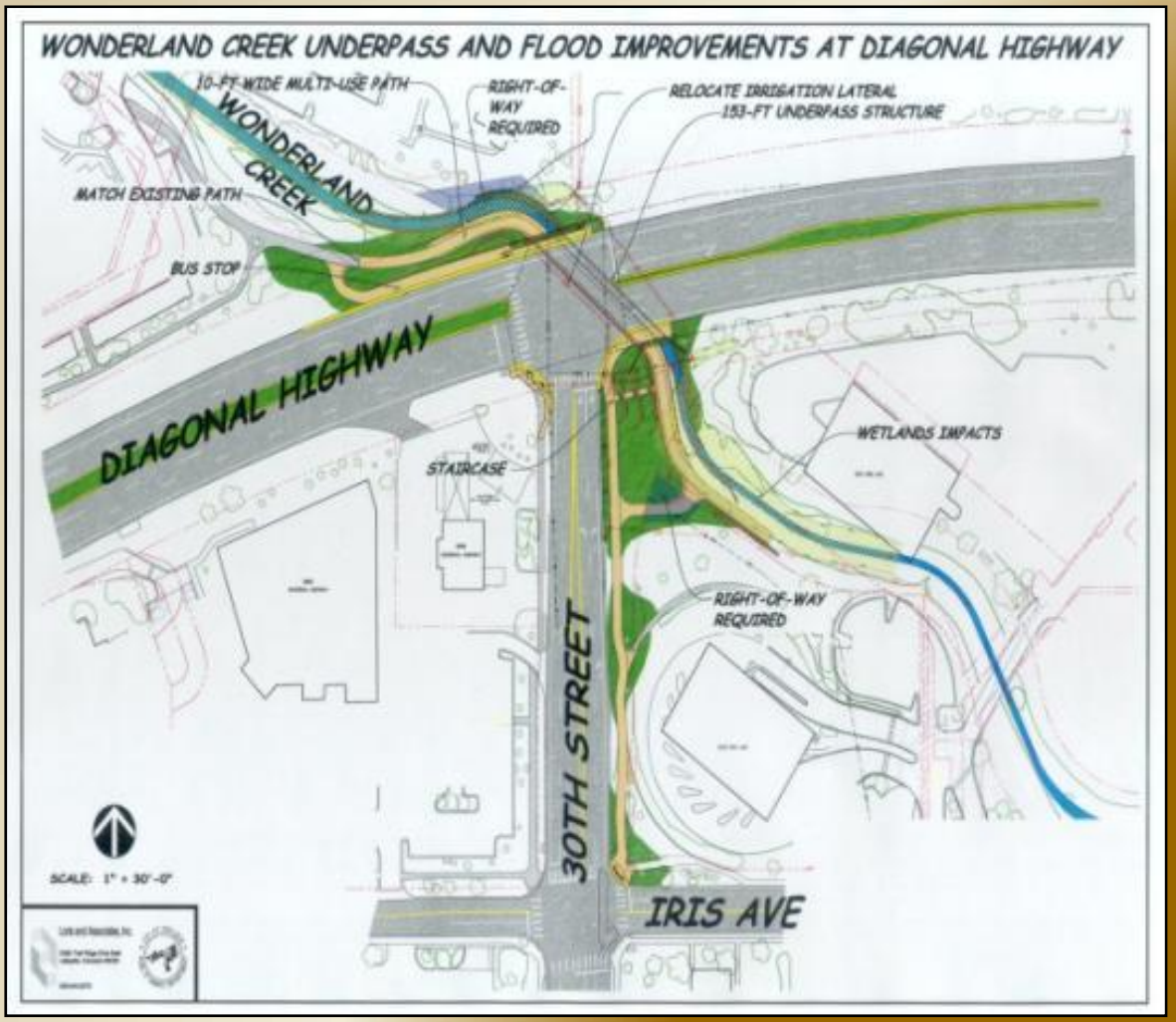
UNDERPASS ISSUES

- ✓ **Feasibility**
- ✓ **Success**

- ✓ **Critical Issues**
  - site constraints
  - constructability
  - structure selection
  - drainage
  - lighting
  - safety



EVALUATING THE SITE



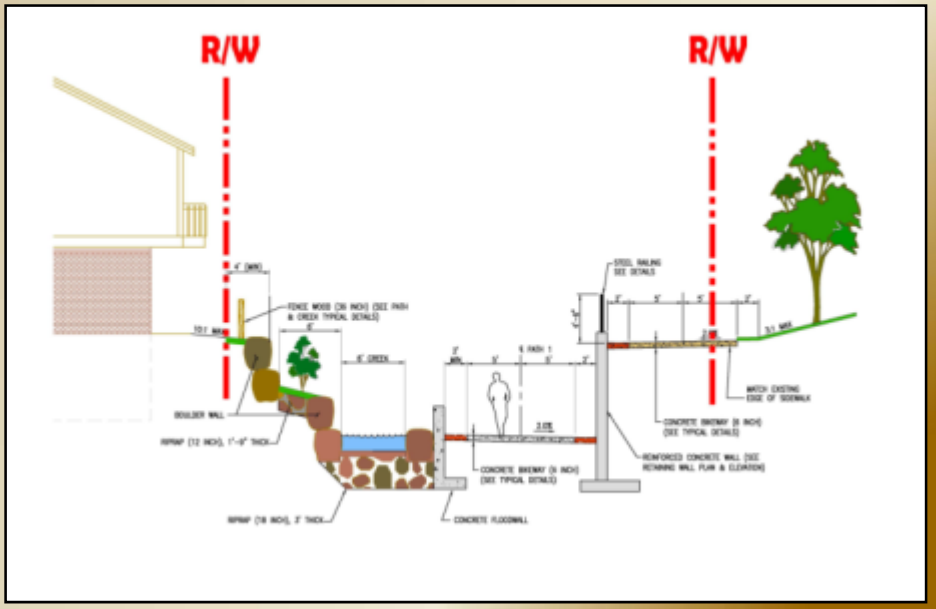
- ✓ Utilities
- ✓ Right of Way
- ✓ Environmental
- ✓ Soil Conditions
- ✓ Traffic Control
- ✓ Drainage

- ✓ At what cost?

UTILITIES

- ✓Locate all utilities and coordinate with owners
- ✓Pothole critical utilities
- ✓Asbestos conduits require special treatment
- ✓Avoid costly utility delays

RIGHT OF WAY

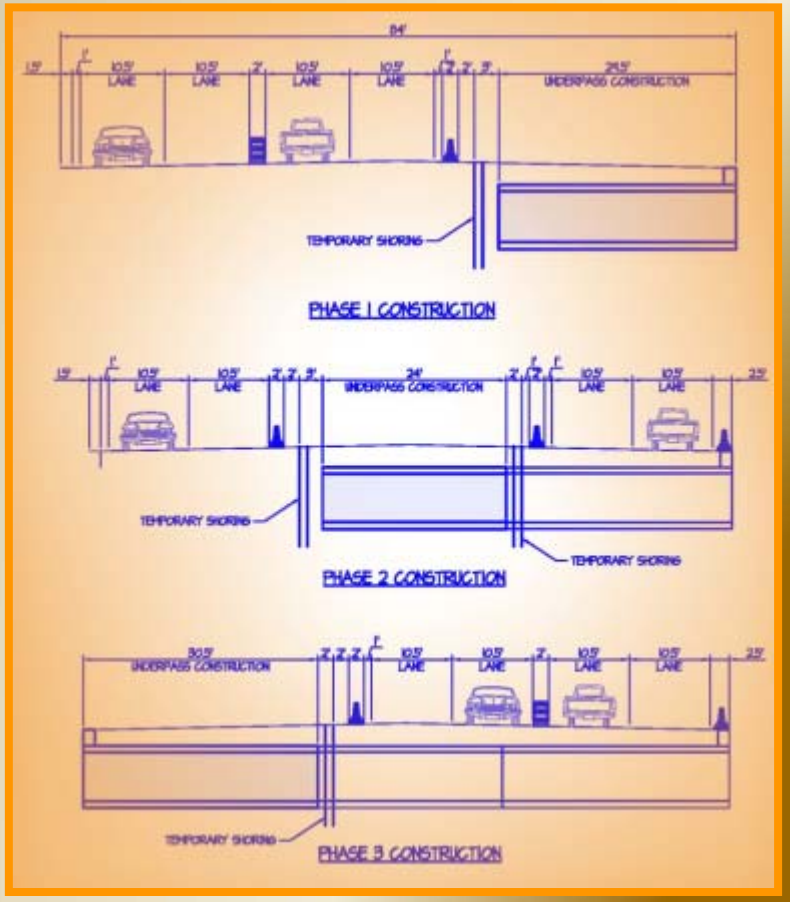


- ✓Identify available right of way
- ✓Consider space required for construction
- ✓Talk with property owners early
- ✓Right of way negotiations can take time

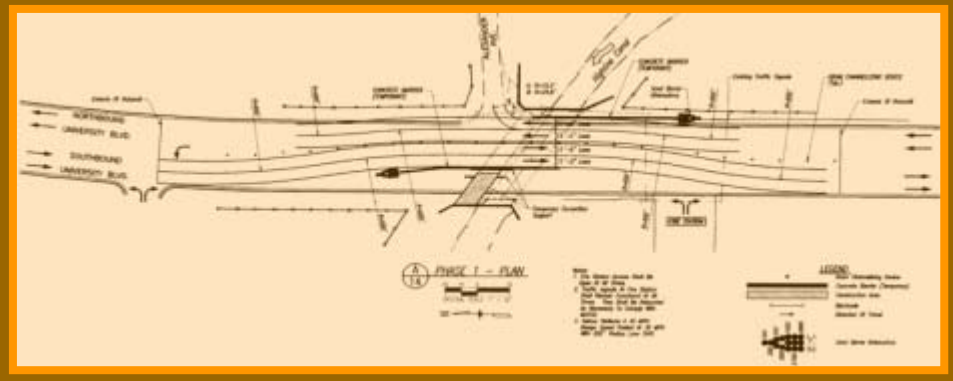
SOIL CONDITIONS

- ✓Hire a geotechnical consultant
- ✓Identify groundwater elevations and soil conditions
- ✓Plan for ground water during and after construction

TRAFFIC CONTROL



- ✓**Consider impacts to traffic during construction**
  - **can the road be closed during construction?**
  - **design speed?**
  - **number of lanes?**
  - **pedestrian and bikes during construction?**



TRAFFIC CONTROL

- ✓Consider impacts to traffic during construction

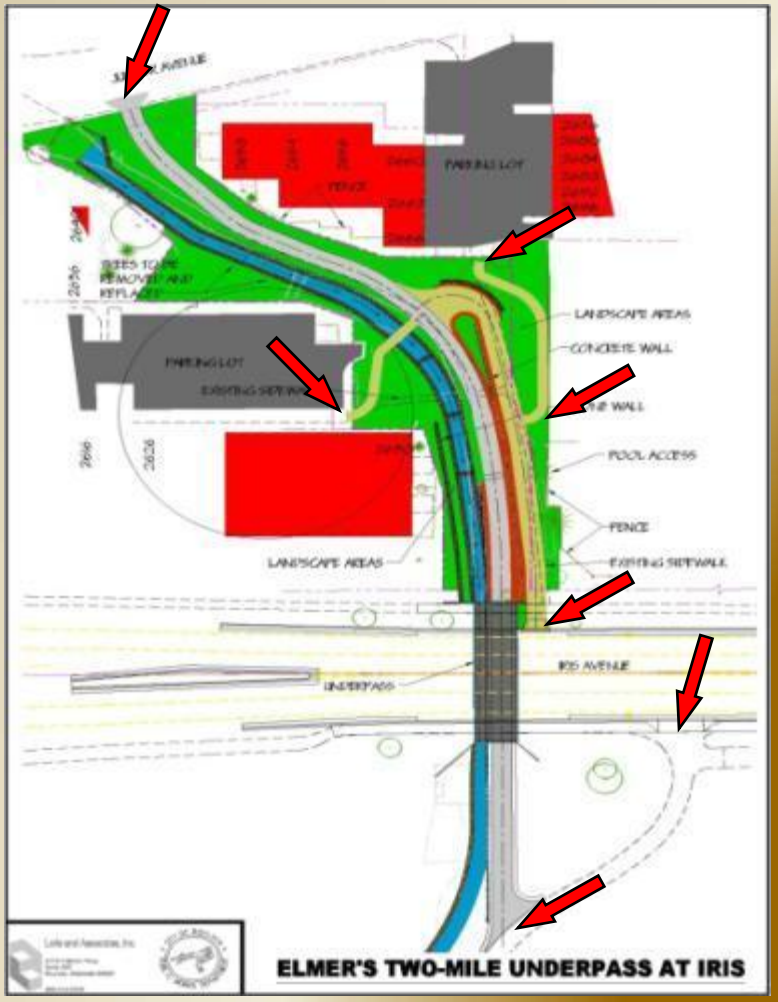
TRAFFIC CONTROL

- ✓Don’t forget pedestrians, bus stops, etc

EVALUATING THE SITE

✓Site challenges have been identified

LAYOUT DESIGN



- ✓ **Identify path connection to at-grade facilities (sidewalks, bus stops…)**
- ✓ **Determine approach grades**
  - **use ADA and AASTHO Bike Guide Requirements**
  - **provide 5% max if possible**
- ✓ **Provide horizontal curves**
  - **consider sight distance**
  - **bicycle movements**
  - **maintenance vehicles**
- ✓ **Consider ramps and stairs, depending on usage**

LAYOUT DESIGN

- ✓ **AASHTO Guide for Development of Bicycle Facilities**
  - 5 - 6% up to 800 ft
  - 7% up to 400 ft
  - 8% up to 300 ft
  - 9% up to 200 ft
  - 10% up to 100 ft
  - 11+% up to 50 ft
- ✓ **ADA Guidelines for Outdoor Developed Facilities**
  - 1:20 (5%) any distance
  - 1:12 (8.33%) up to 200 ft
  - 1:10 (10%) up to 30 ft
  - 1:8 (12.5%) up to 10 ft

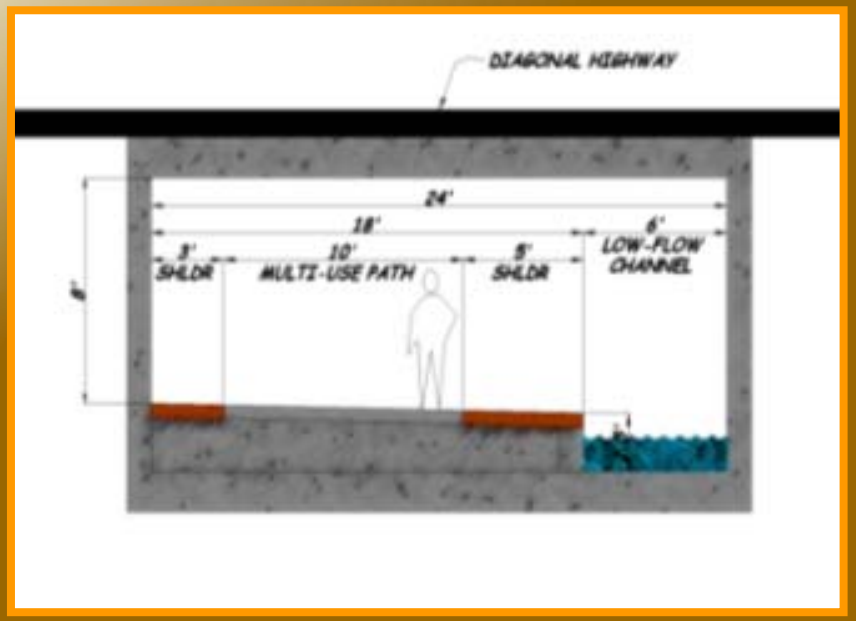
LAYOUT DESIGN

✓ **Provide alternate routes**

LAYOUT DESIGN

✓ **Provide alternate routes**

STRUCTURE SIZING



- ✓ AASTHO: 10-ft vert. clearance
- ✓ 8-ft Vert. is typically acceptable
- ✓ Horiz. clearance of 14-ft min.
- ✓ Consider impacts to utilities and drainage
- ✓ Size for flood conveyance if appropriate
- ✓ Additional height usually adds more to cost than width

STRUCTURE SIZING

- ✓ There are plenty of functional examples less than 8’
- ✓ Provide warnings

STRUCTURE TYPES

Cast-In-Place Concrete

Precast Concrete

Corrugated Steel

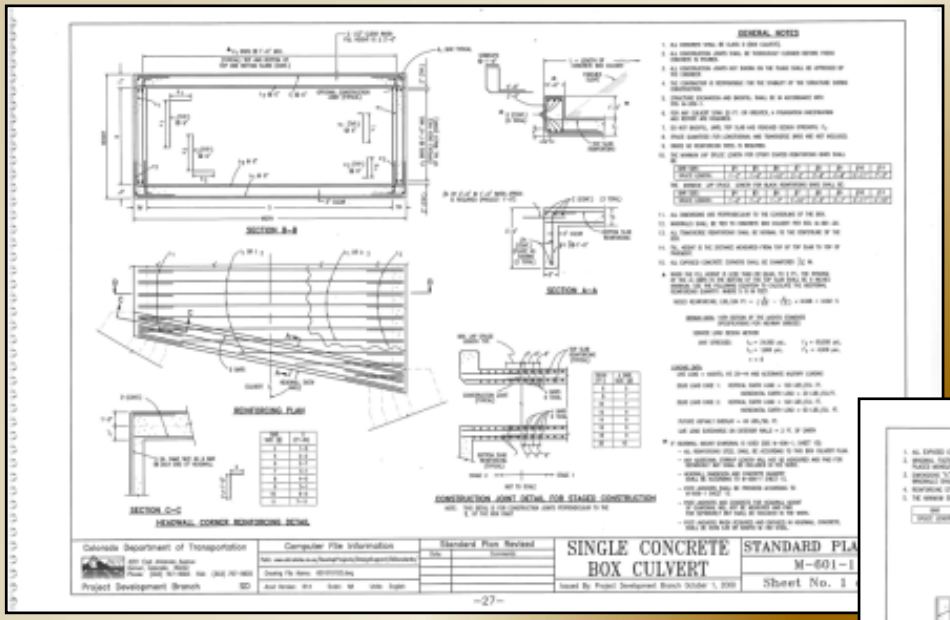
CAST-IN-PLACE CONCRETE

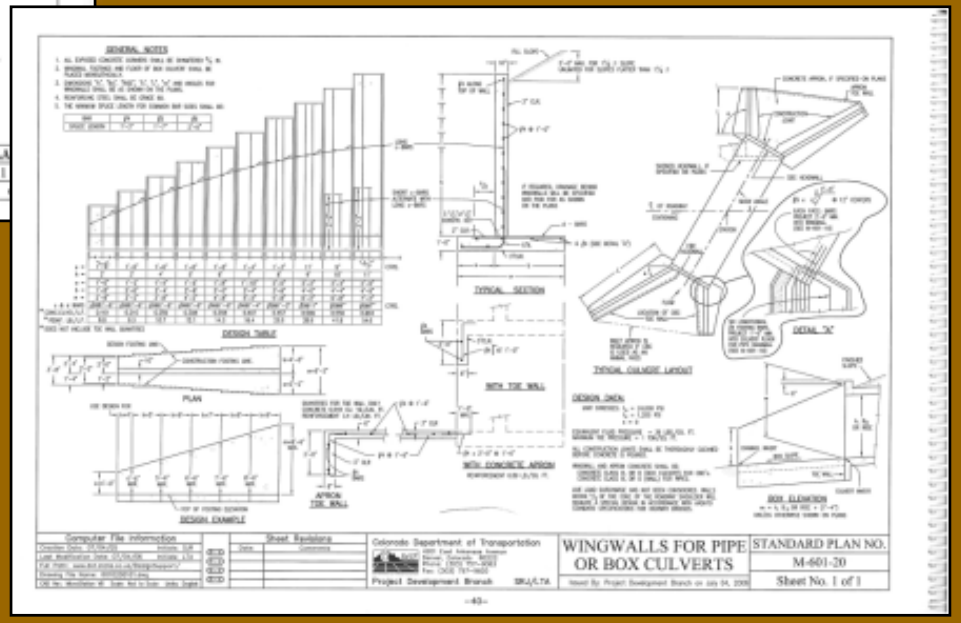
- ✓ **Advantages**
  - can be “customized”
  - no joints
- ✓ **Disadvantages**
  - longer duration of construction
  - cost

CAST-IN-PLACE CONCRETE

- ✓ **Fabrication on site takes time**
- ✓ **Consider impacts to traffic and control of water**

CAST-IN-PLACE CONCRETE

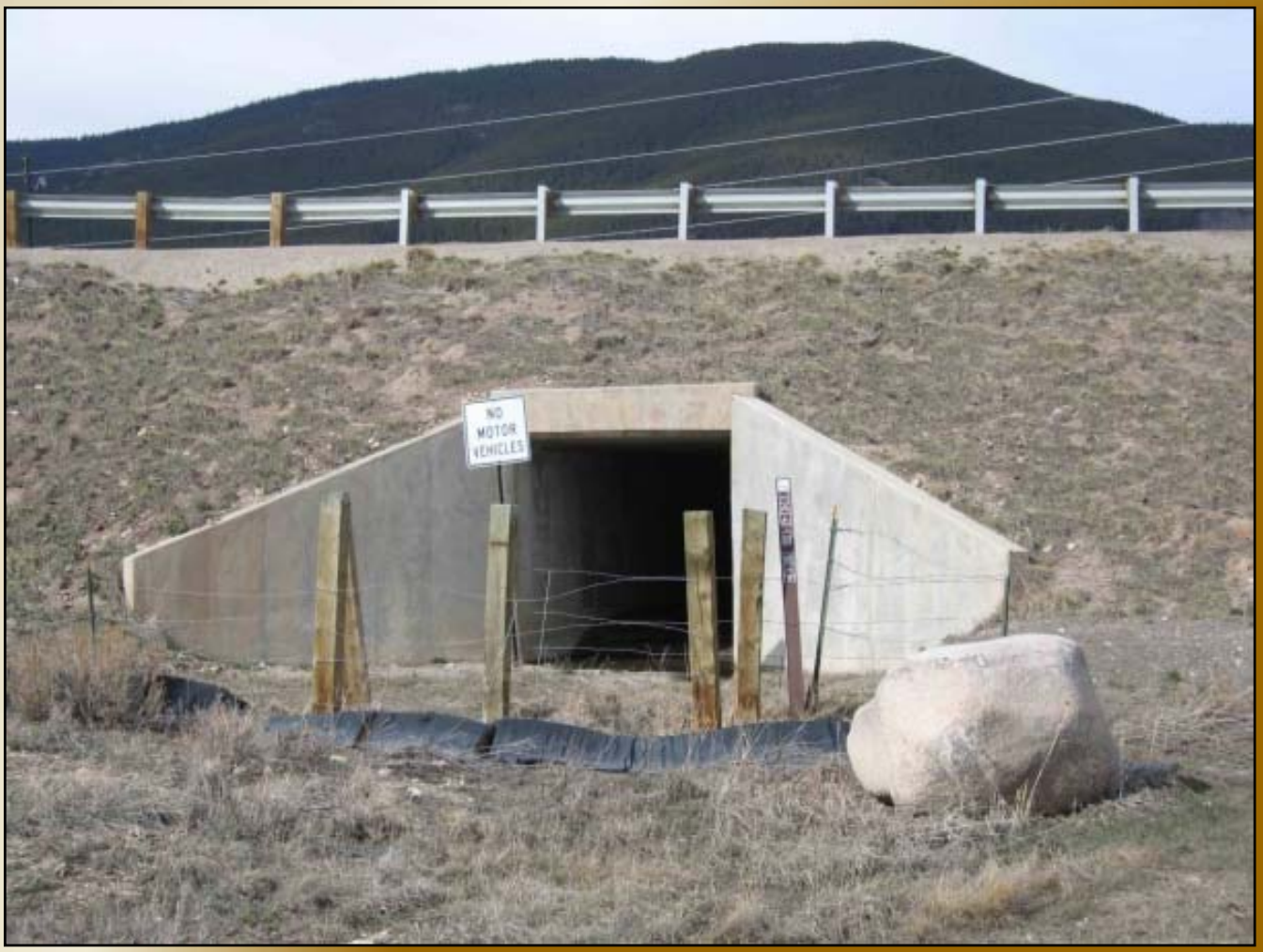




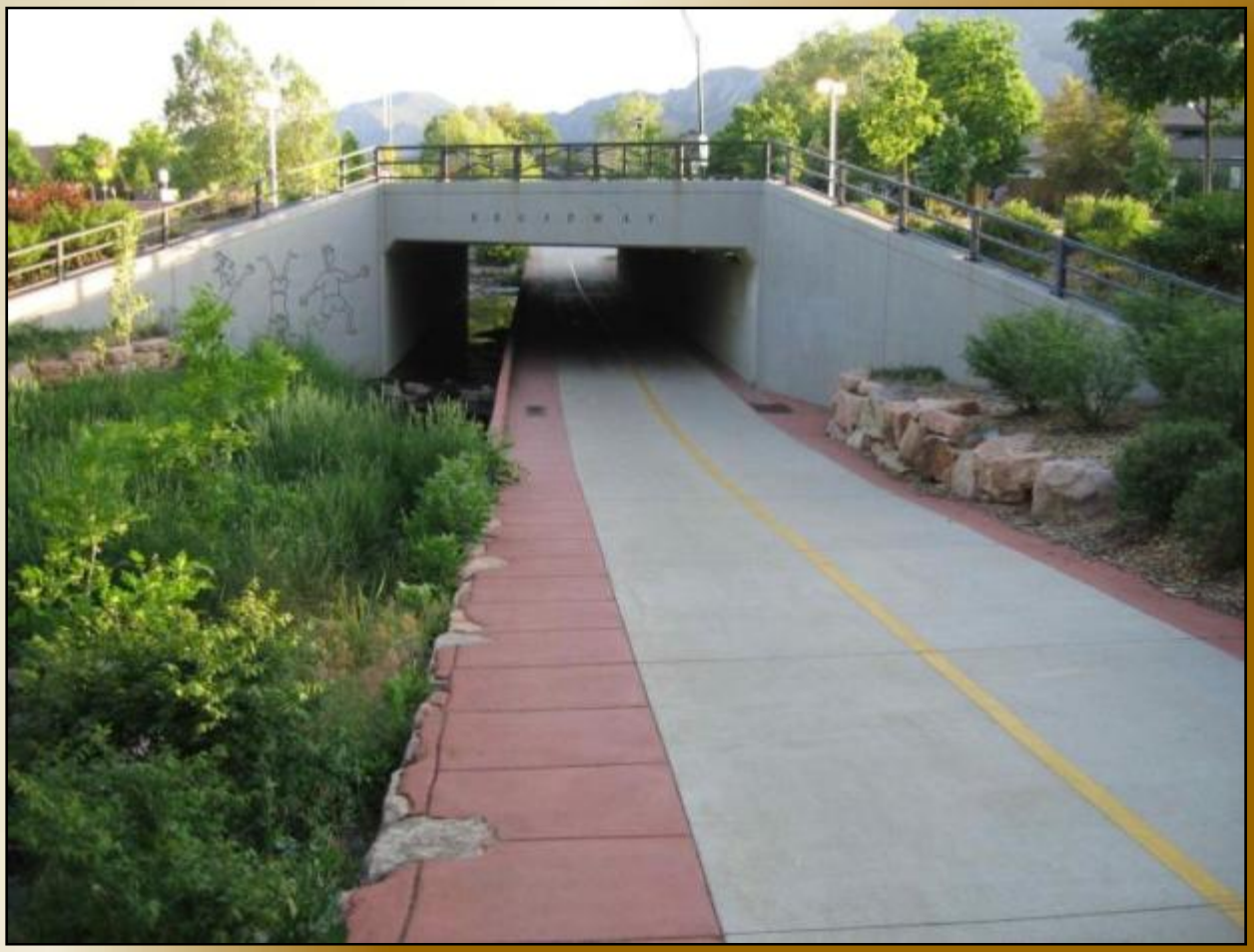
- ✓ **Standard designs are available from many state DOTs**

alta PLANNING + DESIGN

CAST-IN-PLACE CONCRETE



CAST-IN-PLACE CONCRETE



✓ **Combined hydraulic structure**

CAST-IN-PLACE CONCRETE

- ✓ **Enhanced aesthetic structures**

CAST-IN-PLACE CONCRETE

- ✓ Controlled Drainage
- ✓ Textured Surfacing
- ✓ Recessed Lighting

PRECAST CONCRETE

- ✓ **Advantages**
  - quick installation
- ✓ **Disadvantages**
  - less flexibility
  - joints
  - leakage

PRECAST CONCRETE

- ✓ **Three-sided arch structure**

PRECAST CONCRETE

- ✓ Three-sided arch structure
- ✓ Spans up to 35’

PRECAST CONCRETE

- ✓ Delivered to the site in 4’ to 8’ sections
- ✓ Spans up to 15’
- ✓ Base preparation is important

PRECAST CONCRETE

- ✓ 3-sided structures used for longer spans
- ✓ Spans up to 35’
- ✓ Cast-in-place footings required
- ✓ Additional Vertical Clearance Required

PRECAST CONCRETE

- ✓ Joints
- ✓ No control of drainage
- ✓ Surface Mounted Lighting

PRECAST CONCRETE

- ✓ Asphalt paving with curb and gutter

PRECAST CONCRETE

- ✓ Textured surfacing
- ✓ Recessed lighting

PRECAST CONCRETE

- ✓ Waterproof joints from the outside

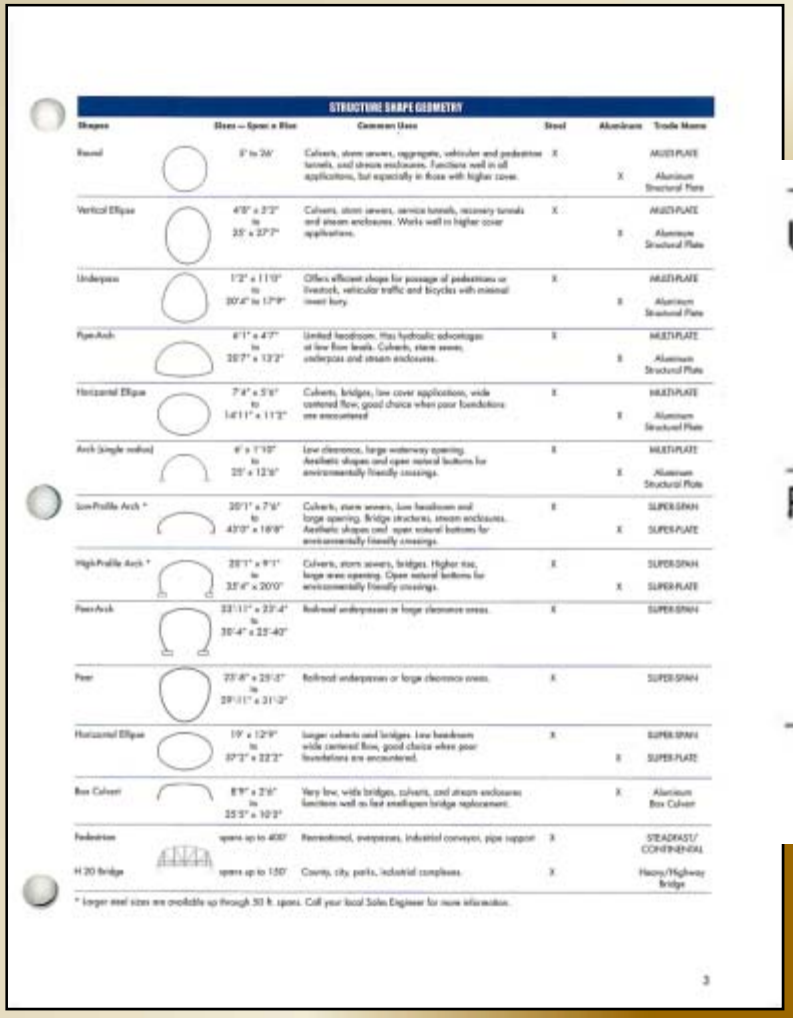
PRECAST CONCRETE

- ✓ **Properly seal and waterproof joints in precast concrete structures**
- ✓ **Avoid using in wet locations**

CORRUGATED STEEL

- ✓ **Advantages**
  - quickest installation
  - least Cost
- ✓ **Disadvantages**
  - less flexibility
  - geometric constraints
  - more vertical clearance needed
  - leakage
  - aesthetics
  - service Life

CORRUGATED STEEL



STRUCTURE SHAPE GEOMETRY

Shapes	Sizes — Span x Rise	Common Uses	Steel	Aluminum	Trade Name
Round	5' to 26'	Culverts, storm sewers, aggregate, vehicular and pedestrian tunnels, and stream enclosures. Functions well in all applications, but especially in those with higher cover.	X		MULTIPLATE
				X	Aluminum Structural Plate
Vertical Ellipse	4'8" x 3'2" to 35' x 23'3"	Culverts, storm sewers, service tunnels, recovery tunnels and stream enclosures. Works well in higher cover applications.	X		MULTIPLATE
				X	Aluminum Structural Plate
Underpass	1'2" x 11'0" to 20'4" to 17'9"	Offers efficient shape for passage of pedestrians or livestock, vehicular traffic and bicycles with minimal invert bury.	X		MULTIPLATE
				X	Aluminum Structural Plate
Pipe-Arch	6'1" x 4'7" to 20'7" x 13'2"	Limited headroom. Has hydraulic advantages at low flow levels. Culverts, storm sewer, underpass and stream enclosures.	X		MULTIPLATE
				X	Aluminum Structural Plate
Horizontal Ellipse	7'4" x 5'6" to 14'11" x 11'2"	Culverts, bridges, low cover applications, wide centered flow, good choice when poor foundations are encountered	X		MULTIPLATE
				X	Aluminum Structural Plate
Arch (single radius)	6' x 1'10" to 25' x 12'6"	Low clearance, large waterway opening. Aesthetic shapes and open natural bottoms for environmentally friendly crossings.	X		MULTIPLATE
				X	Aluminum Structural Plate
Low-Profile Arch *	20'1" x 7'6" to 43'0" x 16'9"	Culverts, storm sewers, Low headroom and large opening. Bridge structures, stream enclosures. Aesthetic shapes and open natural bottoms for environmentally friendly crossings.	X		SUPER-DIMA
				X	SUPER-PLATE
High-Profile Arch *	20'1" x 9'1" to 35'4" x 20'0"	Culverts, storm sewers, bridges. Higher rise, large area opening. Open natural bottoms for environmentally friendly crossings.	X		SUPER-DIMA
				X	SUPER-PLATE
Pear-Arch	22'11" x 23'-4" to 35'-4" x 25'-40"	Railroad underpasses or large clearance areas.	X		SUPER-DIMA
Pear	25'-8" x 25'-1" to 29'-11" x 31'-2"	Railroad underpasses or large clearance areas.	X		SUPER-DIMA
Horizontal Ellipse	19' x 12'9" to 57'3" x 33'3"	Larger culverts and bridges. Low headroom wide centered flow, good choice where poor foundations are encountered.	X		SUPER-DIMA
				X	SUPER-PLATE
Box Culvert	8'9" x 2'6" to 25'5" x 10'3"	Very low, wide bridges, culverts, and stream enclosures functions well as fast small-span bridge replacement.		X	Aluminum Box Culvert
Pedestrian	spans up to 400'	Recreational, overpasses, industrial conveyor, pipe support	X		STEADFAST/ CONTINENTAL
H 20 Bridge	spans up to 150'	County, city, parks, industrial complexes.	X		Heavy/Highway Bridge

* Larger steel sizes are available up through 50 ft. spans. Call your local Sales Engineer for more information.

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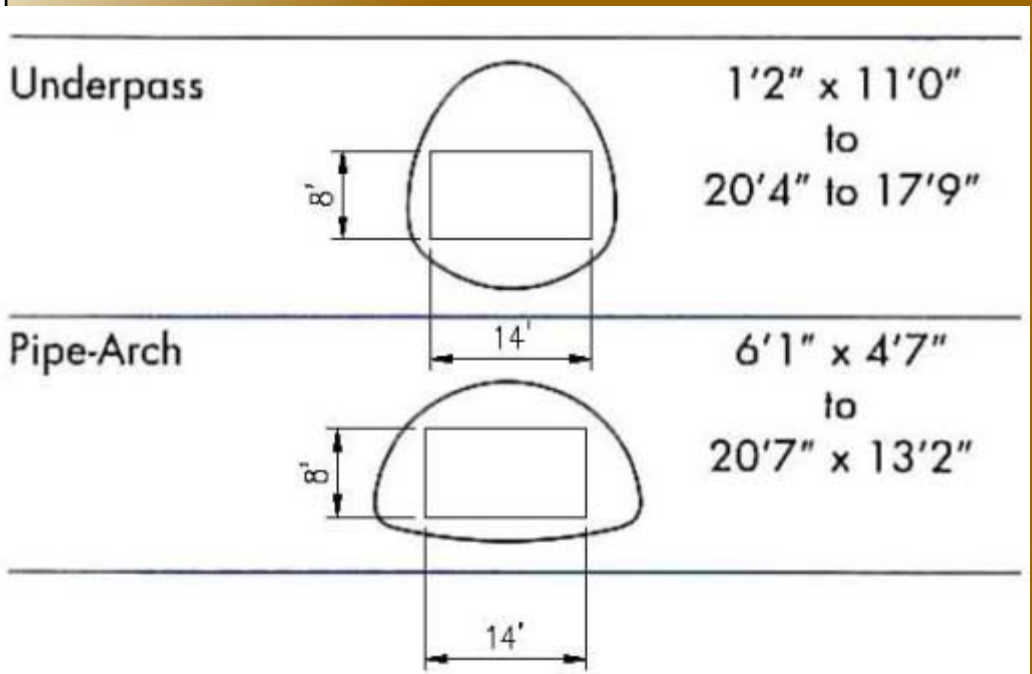


CORRUGATED STEEL

- ✓ **Assembled on site and lifted in place**

CORRUGATED STEEL

✓ Circular pipe

CORRUGATED STEEL

- ✓ Concrete collar required

- ✓ Vertical arch “underpass” shape

CORRUGATED STEEL

- ✓ Three-sided arch

CORRUGATED STEEL

- ✓ Surface mounted lighting

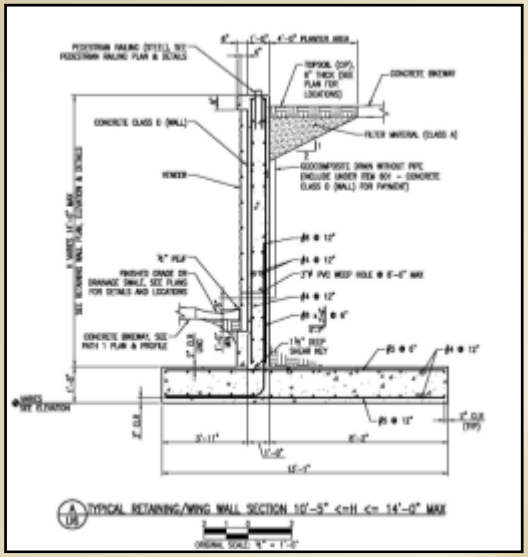
WALL TYPES

Cast-In-Place Concrete

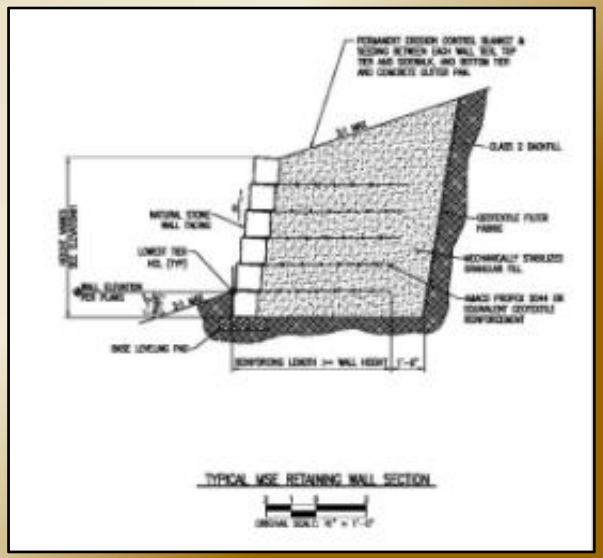
Mechanically Stabilized Earth

Gravity Wall

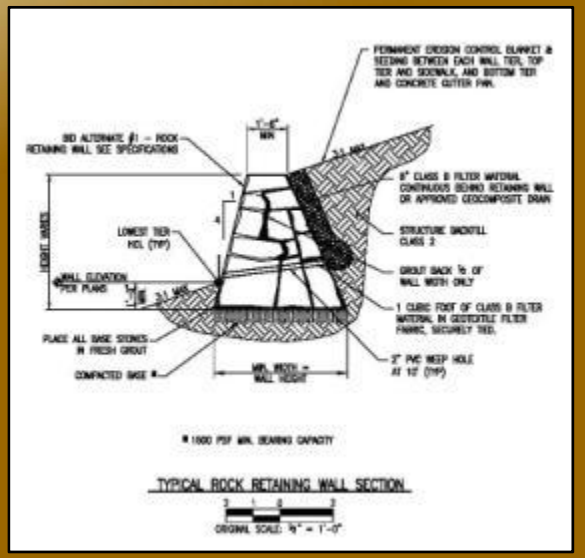
WALL TYPES



Cast-In-Place Concrete
H = 20'+



Mechanically Stabilized Earth
H = 20'+
Reinforcing Needed

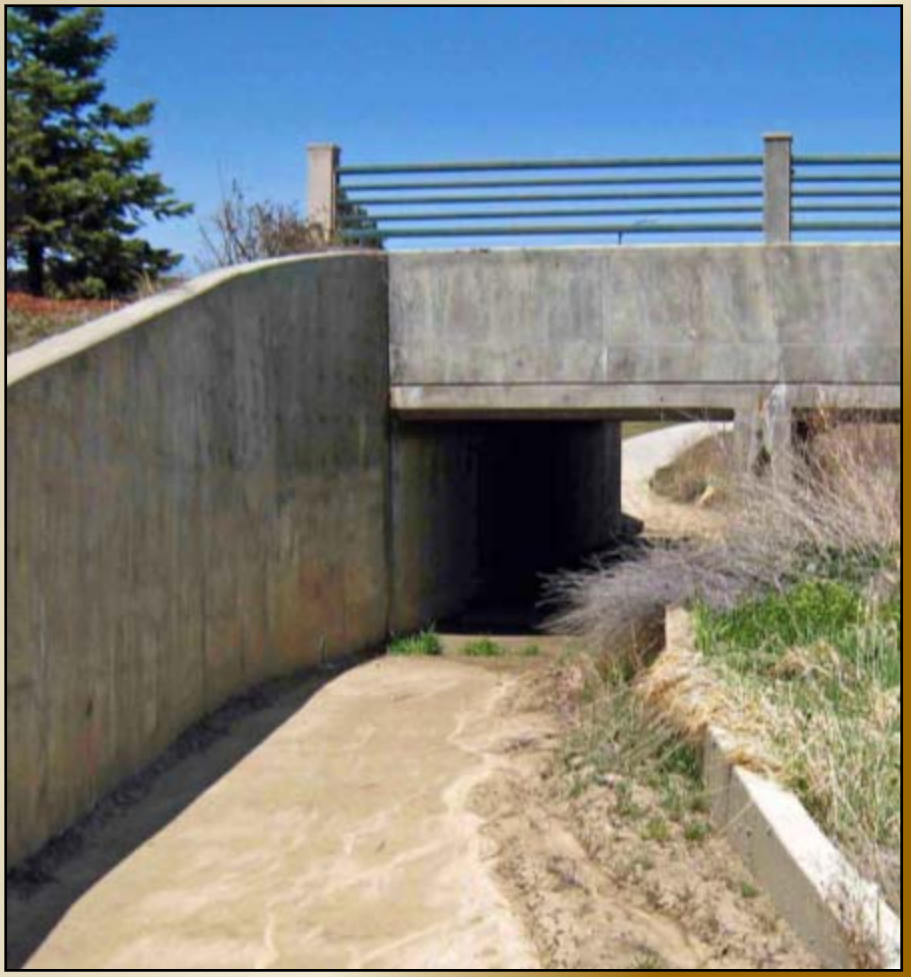


Rock Gravity Wall
H= 4'-5'
Multiple Tears

RETAINING WALLS

- ✓ **Consider constructability issues**

DRAINAGE



- ✓ **Underpasses are low and dark**
  - **drainage is critical**
- ✓ **Avoid cross-path drainage**
- ✓ **Collect drainage before entering underpass**
- ✓ **Consider icing issues**

DRAINAGE

- ✓ Direct water away from path
- ✓ Control water, keep it from crossing path
- ✓ Locate inlets at low points, off travel way

DRAINAGE

- ✓ Controlling water contains debris

DRAINAGE

- ✓ **Better to direct drainage away from path rather than to the center**

DRAINAGE

- ✓ **Better to control drainage and catch it outside the structure**

DRAINAGE

- ✓ **Standing water and debris reduces user value**

DRAINAGE

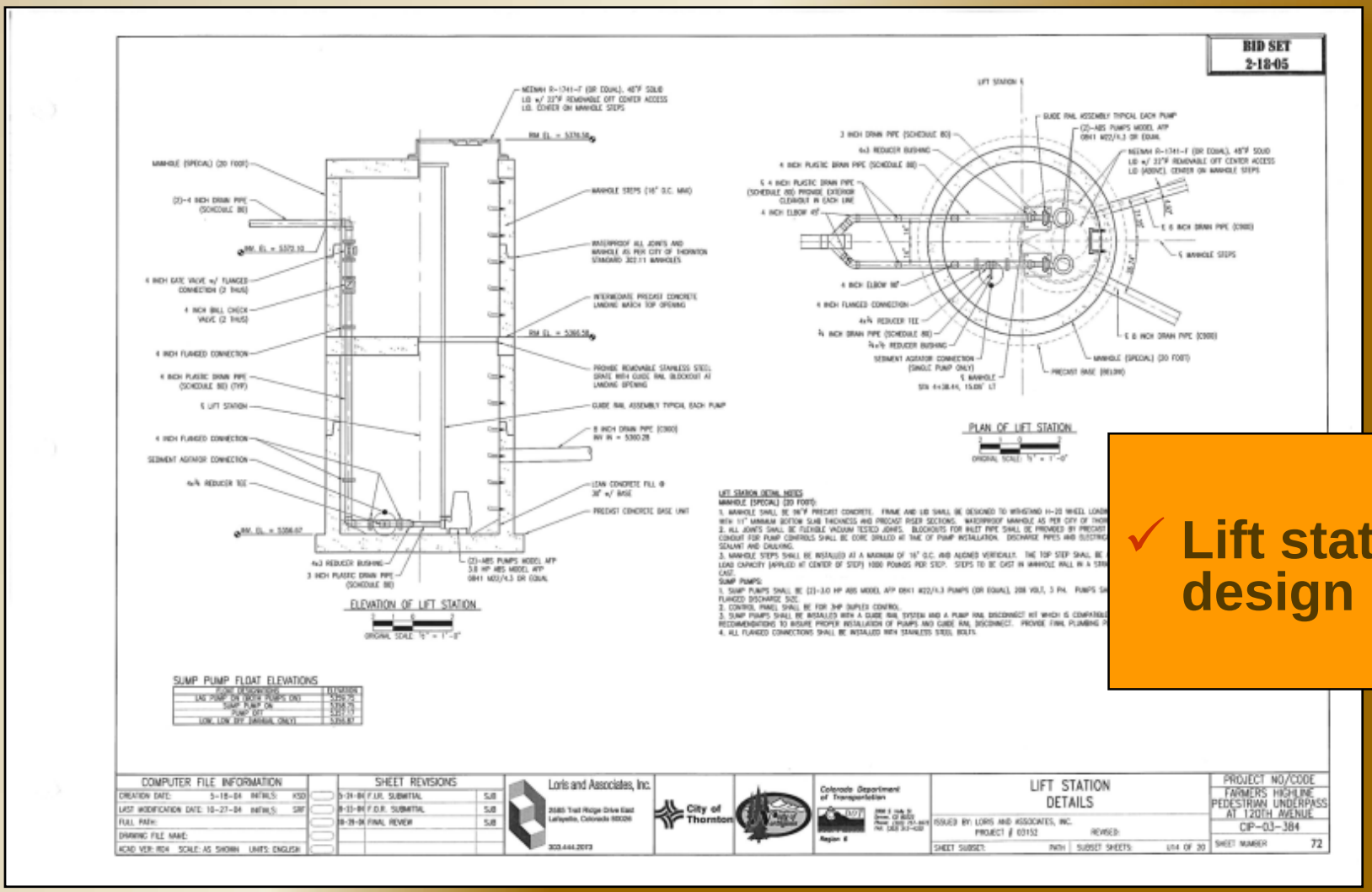
- ✓ **Must provide drainage outfall**

DRAINAGE

- ✓ **Outfall location water surface must be below inlet elevation**
- ✓ **Consider back-flow conditions and flood wall heights**

DRAINAGE

DRAINAGE



✓ **Lift station design**

alta PLANNING + DESIGN

DRAINAGE

- ✓ **Provide access to lift station and control panel**

DRAINAGE

- ✓ **Avoid Drainage Mistakes!**

LIGHTING

- ✓ Natural and artificial lighting
- ✓ Balance interior and exterior light
- ✓ Provide approach lighting
- ✓ Vandal resistance & maintenance

LIGHTING

- ✓ **Various levels of vandal resistance and aesthetics available**

LIGHTING

- ✓ **Lighting is most critical in long structures**
- ✓ **Bright interior color helps**

LIGHTING

- ✓ **Skylights**
  - provide natural light
  - brighten long underpasses
  - Median required

LIGHTING

- ✓ **Provide approach lighting**

SAFETY CONSIDERATIONS

- ✓ **Safety Concerns**
  - collisions / user conflicts
  - wipe-outs

- ✓ **Safety Solutions**
  - channelize / separate users
  - provide adequate visibility
  - control speeds
  - control water / ice / debris
  - provide slope protection (railings and barriers)

- ✓ **CONSIDER THESE THROUGHOUT THE DESIGN**

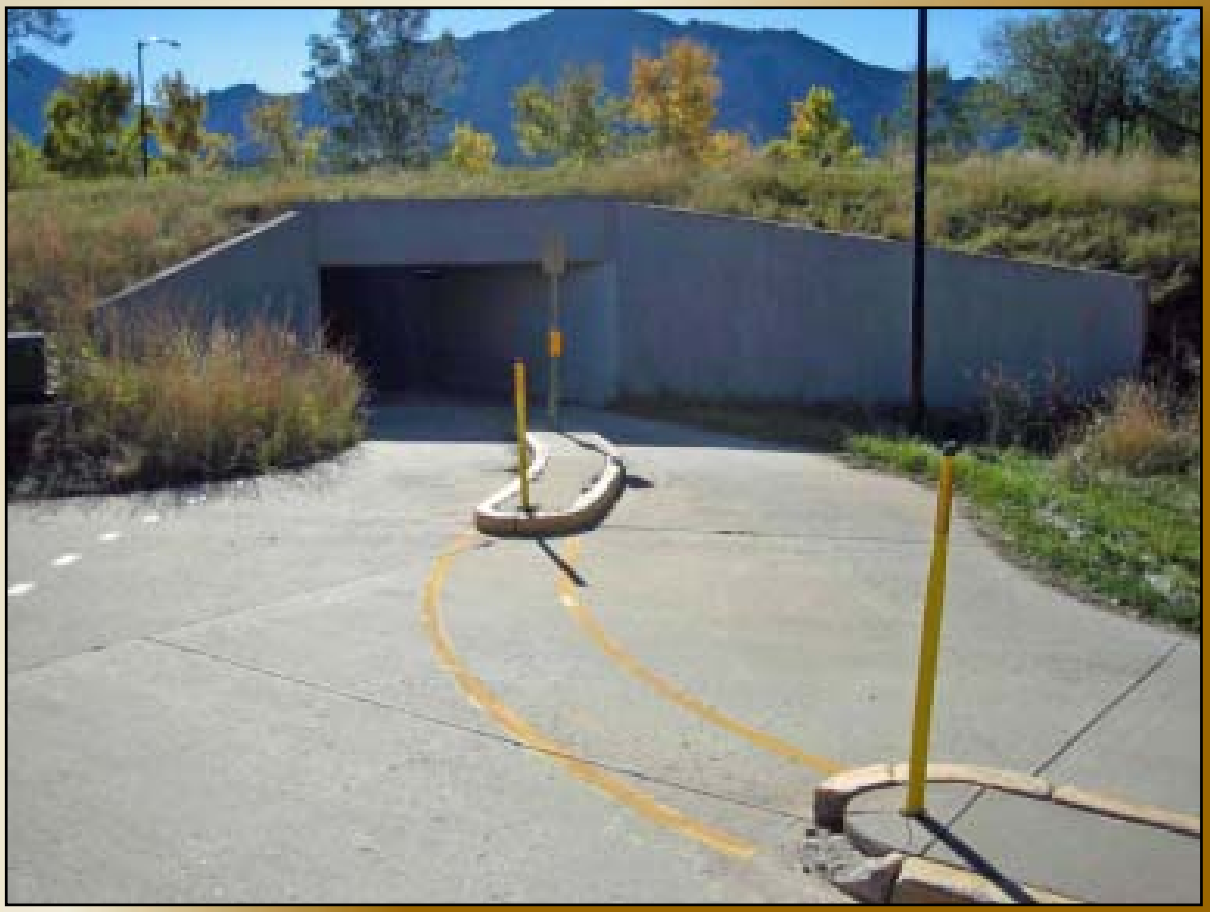
SAFETY CONSIDERATIONS

- ✓ **Provide warnings and channelization**

SAFETY CONSIDERATIONS

✓ Center striping

SAFETY CONSIDERATIONS



- ✓ **Island channelization to improve user separation**

SAFETY CONSIDERATIONS

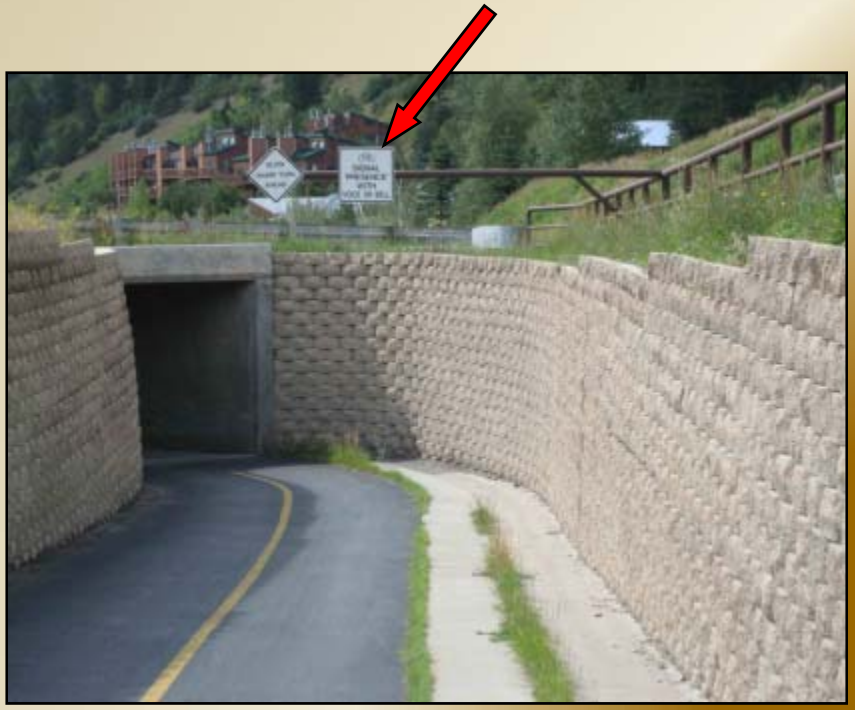
SAFETY CONSIDERATIONS

- ✓ **Don’t encourage conflicts**

SAFETY CONSIDERATIONS

✓ **Enhance sight lines with mirrors**

SAFETY CONSIDERATIONS



✓ **Provide warnings**

SAFETY CONSIDERATIONS

✓ **Control user movements**

SAFETY CONSIDERATIONS

✓ **Delineate edges**

SAFETY CONSIDERATIONS

- ✓ **Control speed**

SAFETY CONSIDERATIONS

✓ **Consider visibility**

ESTIMATING UNDERPASS COST

- ✓ Underpass Structure $100-$200 / SF …… 14’x100’=$140k - $280k
- ✓ Temporary Traffic Control ……$50k - $200k
- ✓ Concrete Path $4 - $8 / SF …… 10’x600’=$24k - $48k
- ✓ Drainage ……$5k - $50k
- ✓ Lighting ……$5k - $25k
- ✓ Pavement Restoration $2 - $4 / SF …… 100’x75’ = $15k - $30k
- ✓ Railings $50 -$200 / LF …… x100’ = $5k - $20k
- ✓ Retaining Walls $20 - $60 / SF …… 15’x100’ = $30k - $90k
- ✓ Landscape……?????????
- ✓ Utilities……?????????
- ✓ Right of Way……?????????

UNDERPASS PROJECTS OFTEN COST $500k TO OVER $2 MIL

DECISION-MAKING PROCESS

Question 6:

What are the details?

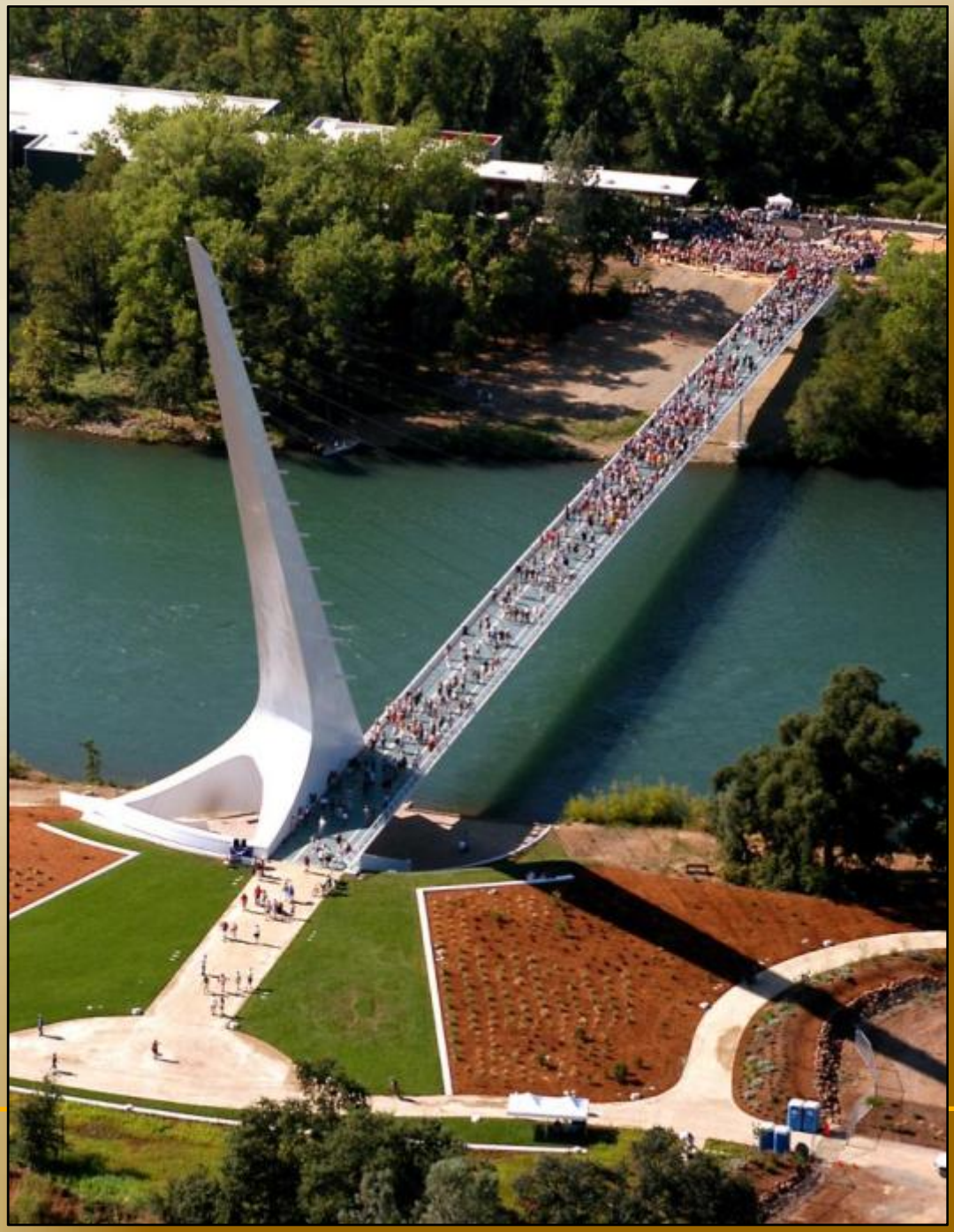
- ✓ Pedestrian Overpass

PURPOSE OF BRIDGE

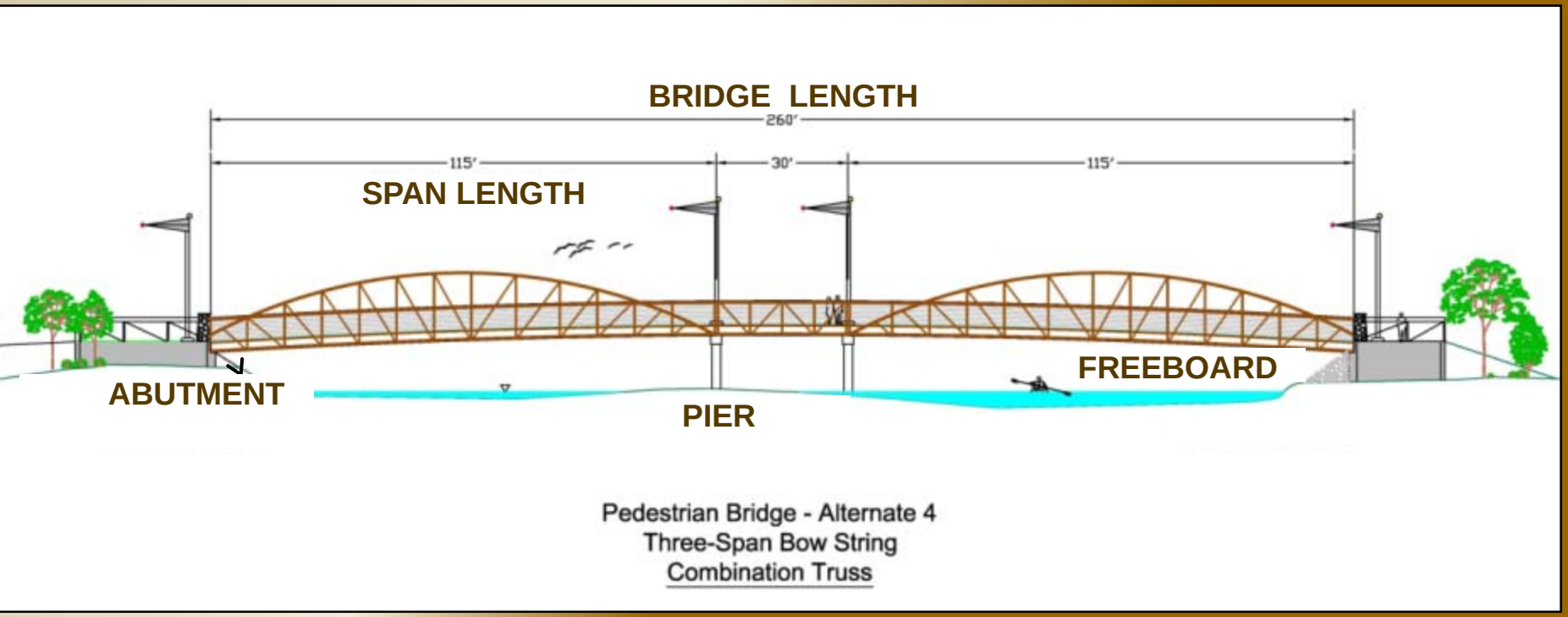
- ✓ **Functional**
  - **aesthetics don't matter**
  - **low cost is everything**

- ✓ **Statement**
  - **gateway**
  - **community icon**
  - **cost doesn't matter**

On a system of Functional Bridges try to include a Statement Bridge every now and then!!!



BRIDGE NOMENCLATURE



Pedestrian Bridge - Alternate 4
Three-Span Bow String
Combination Truss

TRAFFIC BRIDGE ISSUES

- ✓ **Critical Issues**
  - bridge selection
  - ramp length & configuration
- ✓ **Other Issues**
  - constructability
  - railings
  - lighting

RIVER BRIDGE ISSUES

- ✓ **Critical Issues**
  - bridge selection
  - river impact
  - constructability
- ✓ **Other Issues**
  - railings
  - lighting

DESIGN LOADS

- ✓ Dead Load ~ Structure Self Weight
- ✓ Pedestrian Load
  - 85 psf AASHTO
  - reduce per span length (65 psf min)
- ✓ Vehicle Load
  - maintenance (10,000 lb typical)
  - emergency (54,000 lb)
  - Snow Cat (6,000 lb)
  - equestrian
- ✓ Snow, Wind, Thermal & Earthquake

CLEARANCES

✓ Vertical

- Street & Highway ~ AASHTO ~ 16.5’
- Railroad ~ AREMA ~ 25.0’
- River
  - Local ~ 2’ min. over 100-year event
  - DOT ~ $F=0.89*Q^{0.3}+0.26*V^{2}$

✓ Horizontal

- Approach width plus 2’ recommended
- Approach width plus 0’ common

BRIDGE TYPES

Girder	• Short Spans • 5’ to 100’
Truss	• Medium Spans • 20’ to 150’
Arch	• Medium Spans • 50’ to 300’
Cable Stay	• Long Spans • 100’ to 300’
Suspension	• Long Spans • 200’ to 500’

SUPERSTRUCTURE COSTS

BRIDGE AESTHETICS

- ✓ **Integral to Bridge Structure**
  - truss
  - arch
  - cable Stay
  - suspension
- ✓ **Add-on aesthetics**
  - railings
  - pilasters at abutments
  - veneers

Try to make the bridge crossing and viewing experience memorable!!!

GIRDER BRIDGE

- ✓ **Material Types**
  - steel
  - concrete
  - timber
- ✓ **Advantages**
  - many fabrication & construction options
  - unique identity with railing
  - cost ~ $75 - $150 / sf
- ✓ **Disadvantages**
  - girder depth & vertical clearance

STEEL

STEEL

CONCRETE

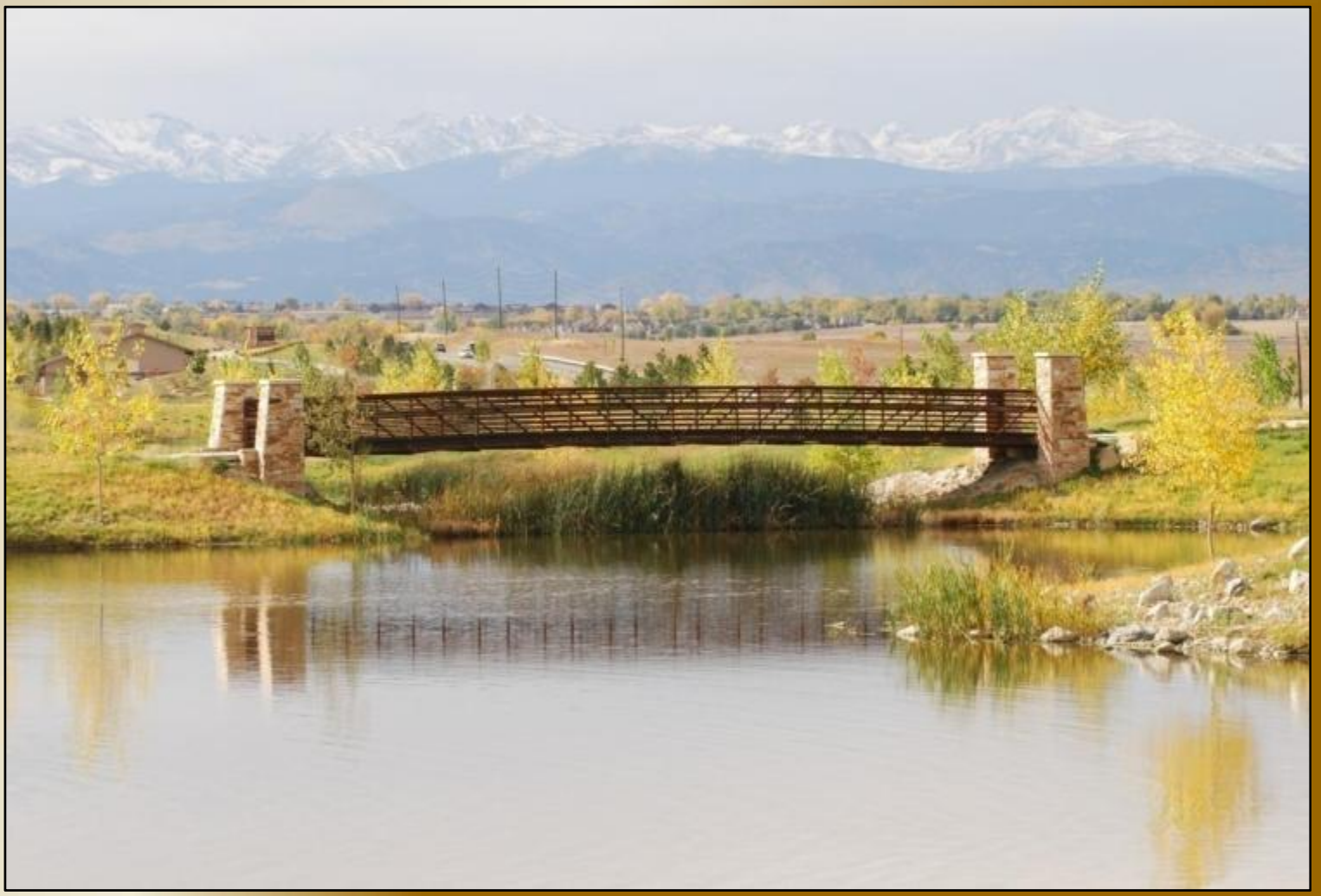
TIMBER

TIMBER

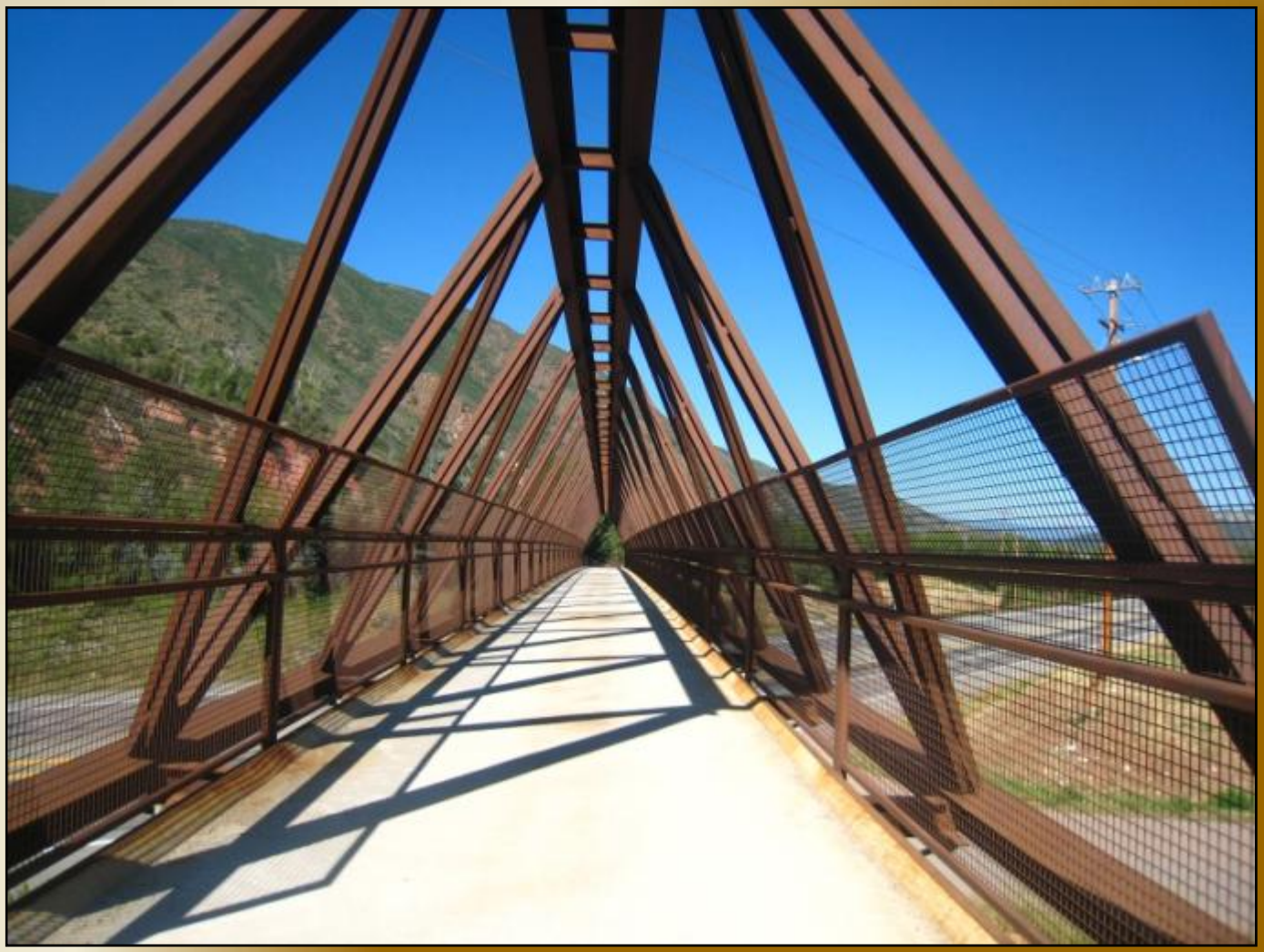
TRUSS BRIDGE

- ✓ **Material Types**
  - steel
  - timber
  - fiberglass (FRP)
- ✓ **Advantages**
  - fitting aesthetics
  - railing integral with structure
  - easy construction
  - installs quickly
  - cost ~ $75 - $150 / sf
- ✓ **Disadvantages**
  - lead time
  - “common” look

TRUSS BRIDGE



TRUSS BRIDGE



TRUSS BRIDGE

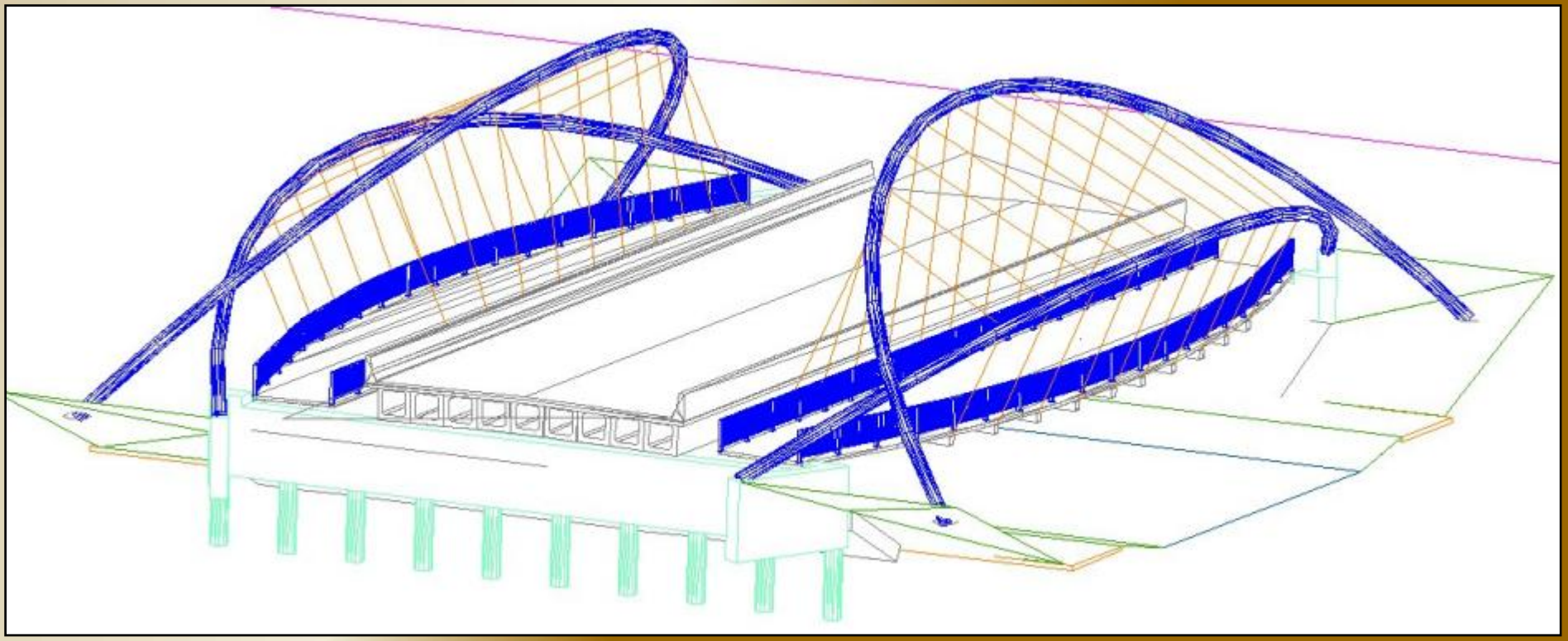
ARCH BRIDGE

- ✓ **Material types**
  - steel
  - concrete
  - timber
- ✓ **Advantages**
  - graceful aesthetics
  - low below trail profile
- ✓ **Disadvantages**
  - cost ~ $150 - $300 / sf

ARCH BRIDGE

ARCH BRIDGE

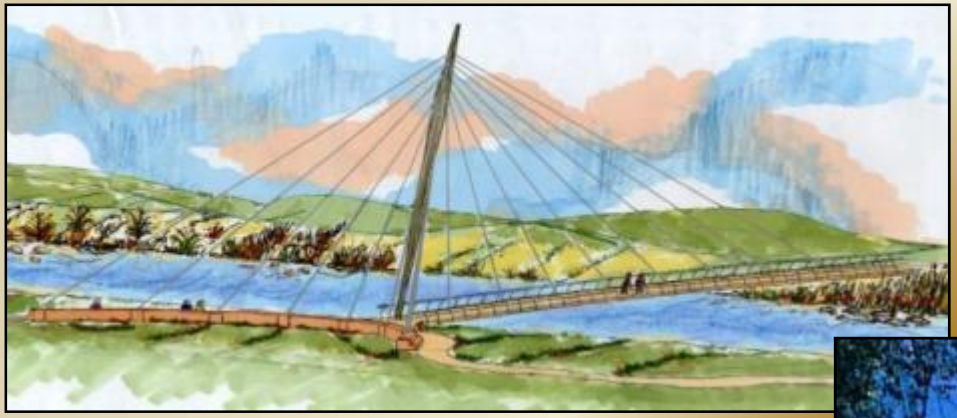
ARCH BRIDGE



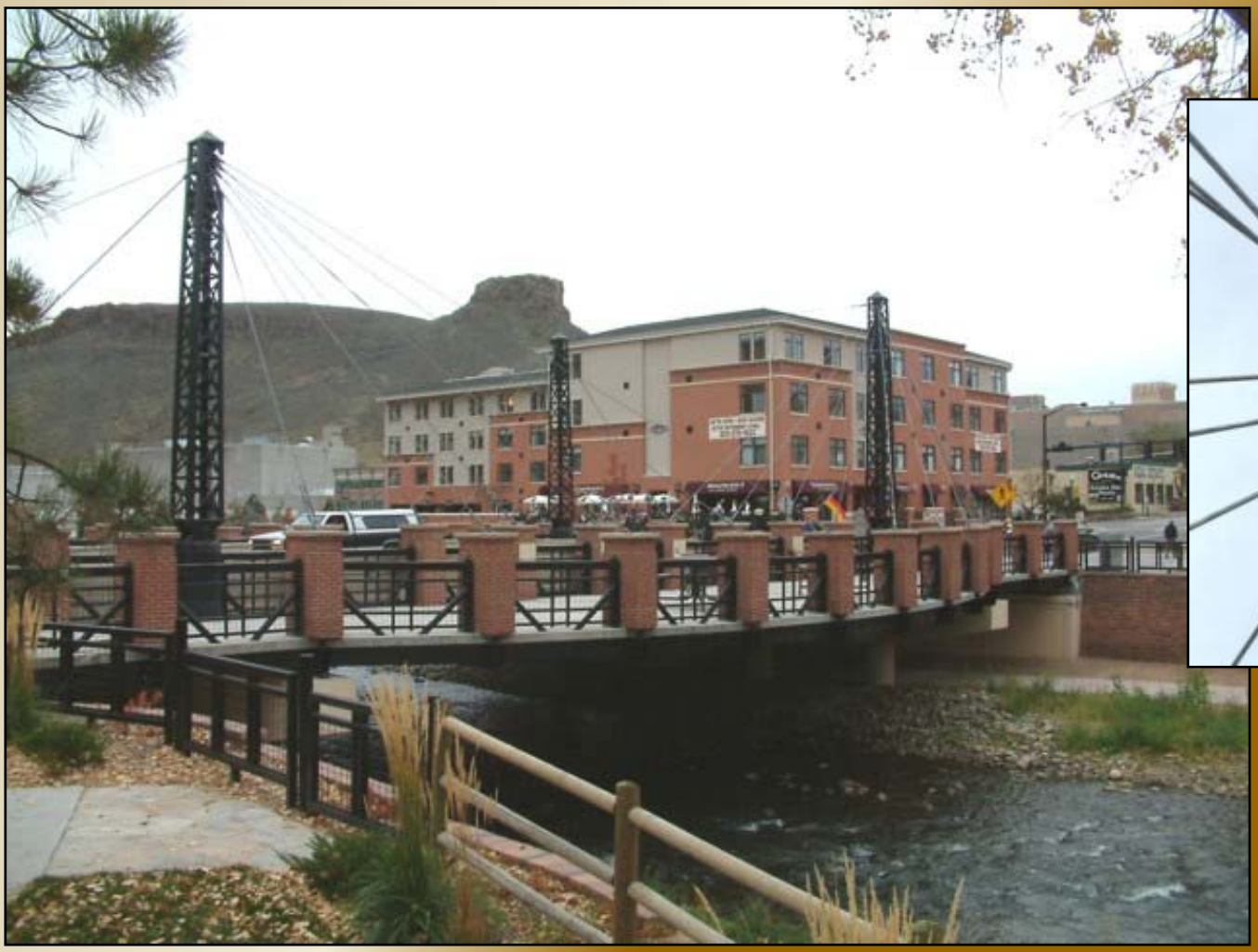
CABLE STAY BRIDGE

- ✓ **Material Types**
  - steel
  - timber
  - concrete
- ✓ **Advantages**
  - aesthetics
  - long span
  - low profile
- ✓ **Disadvantages**
  - cost ~ $400 - $500 / sf
  - few contractors

CABLE STAY BRIDGE



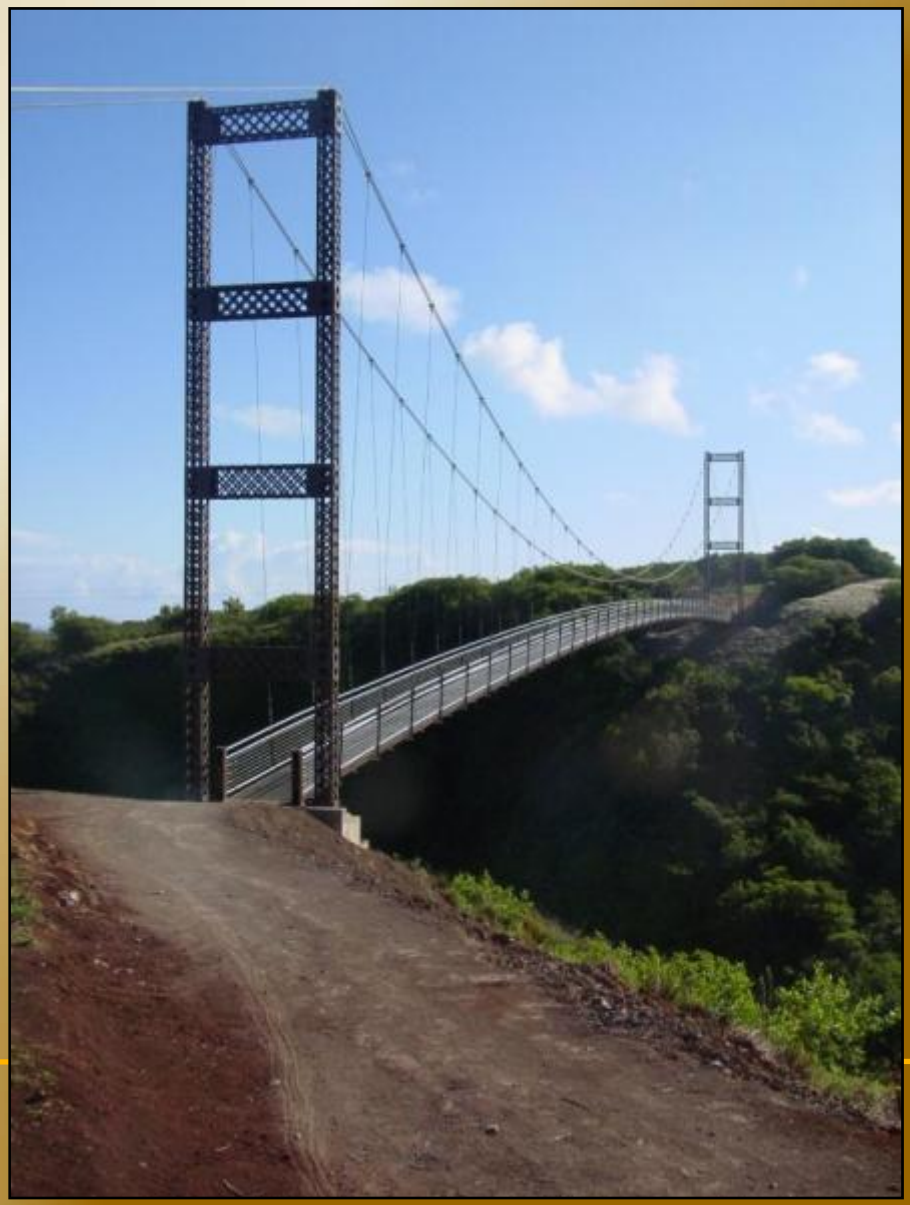
CABLE STAY BRIDGE



SUSPENSION BRIDGE

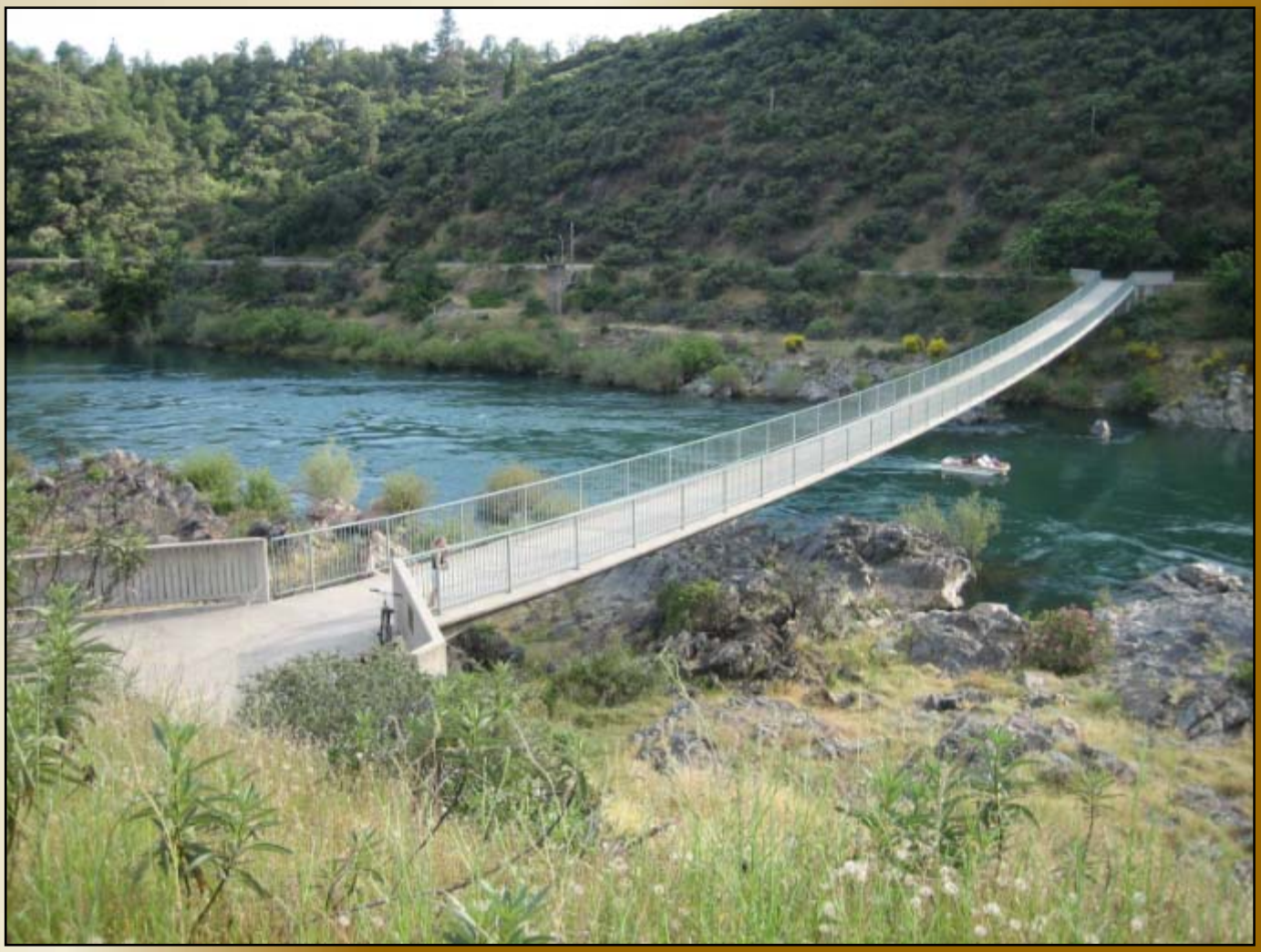
- ✓ **Material Types**
  - steel
  - concrete
  - timber
- ✓ **Advantages**
  - long river crossings
  - graceful aesthetics
  - inaccessible pier locations
- ✓ **Disadvantages**
  - few contractors
  - cost ~ $400 - $500 / sf

SUSPENSION BRIDGE



SUSPENSION BRIDGE

SUSPENSION BRIDGE



APPROACH RAMPS

- ✓ Use ADA Guidelines
- ✓ Long Ramps Due to Vertical Clearances
  - 370’ at 5%
  - 225’ at 8.33%
- ✓ Significant “Overlooked” Cost

APPROACH RAMPS

APPROACH RAMPS

APPROACH RAMPS

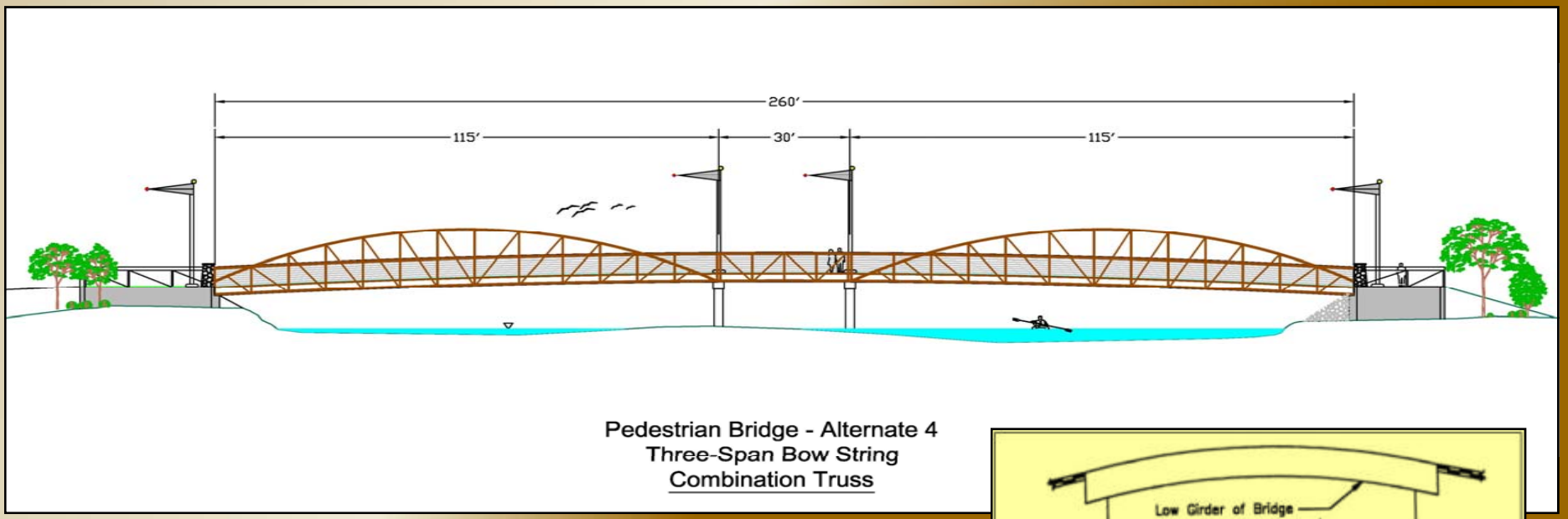
ABUTMENTS & PIERS

- ✓ **Types**
  - footings
  - piles*
  - caissons*
  - helical/screw
- ✓ **Cost**
  - abutment ~ $5,000 to $15,000
  - pier ~ $5,000 to $25,000
- ✓ **Requires soils investigation & utility locates**

* Preferred when scour is possible

BENEFIT OF PIERS

IMPACT TO RIVER



Pedestrian Bridge - Alternate 4
Three-Span Bow String
Combination Truss

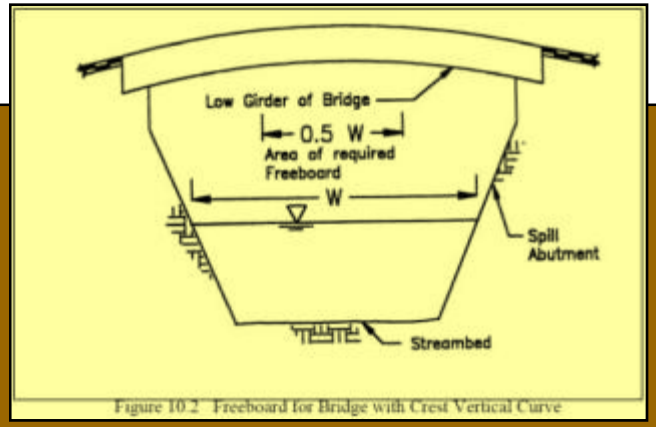
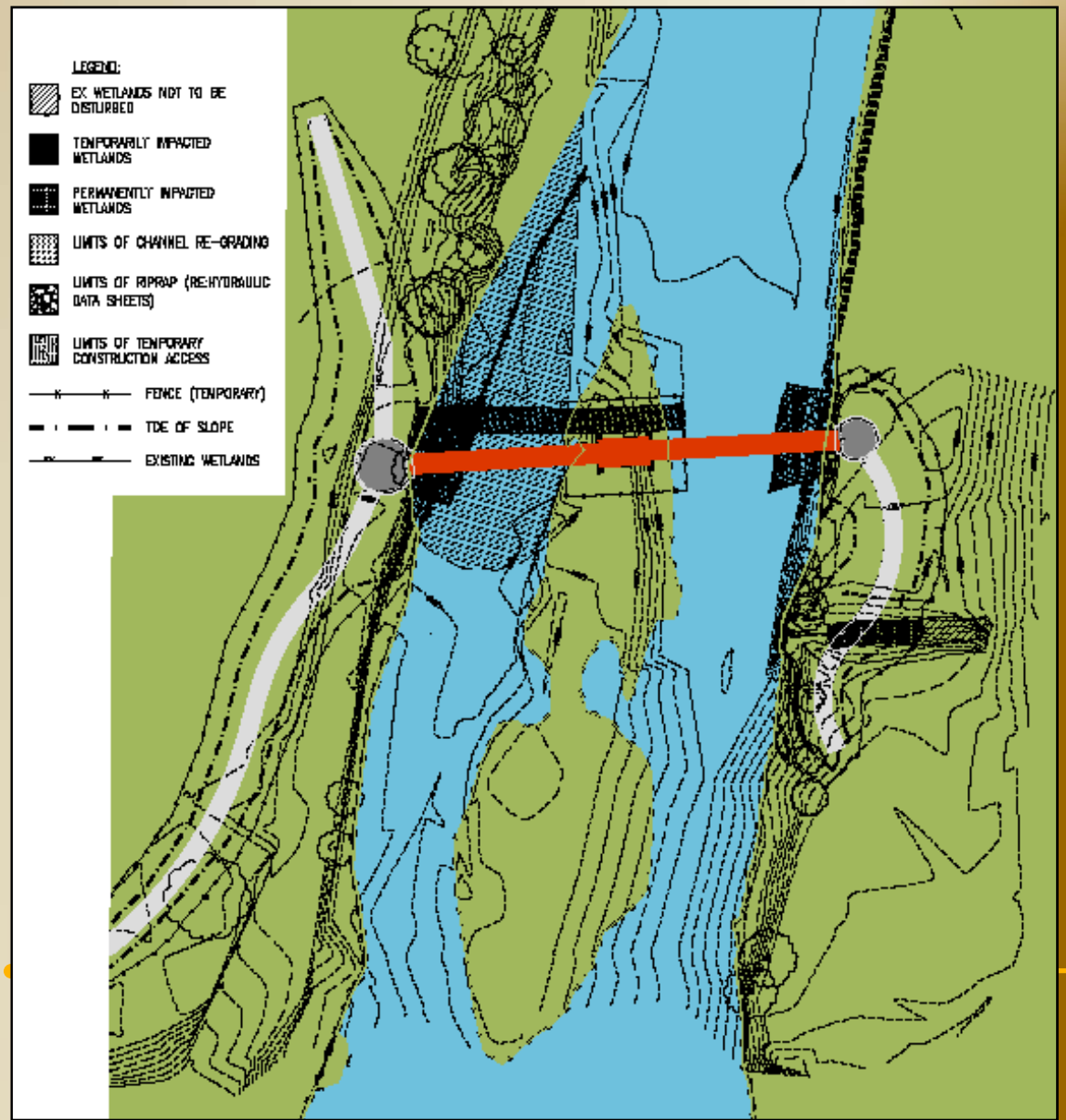


Figure 10.2 Freeboard for Bridge with Crest Vertical Curve

- ✓ **Regulatory Requirements**
- ✓ **Freeboard & Bridge Depth**
- ✓ **Approach Embankments**

IMPACT TO RIVER



- ✓ Number of Piers
- ✓ Scour Protection
- ✓ Construction
- ✓ Wetland Impact
- ✓ Mitigation

BRIDGE RAILINGS

- ✓ **Urban & High Risk Areas ***
  - IBC-based
  - 42” high
  - 4” sphere to 34”, 8” sphere above 34”

- ✓ **Highway Overpass**
  - 2” sphere to 7’-10”

* USFS Trail Bridge Catalogue

BRIDGE RAILINGS

BRIDGE RAILINGS

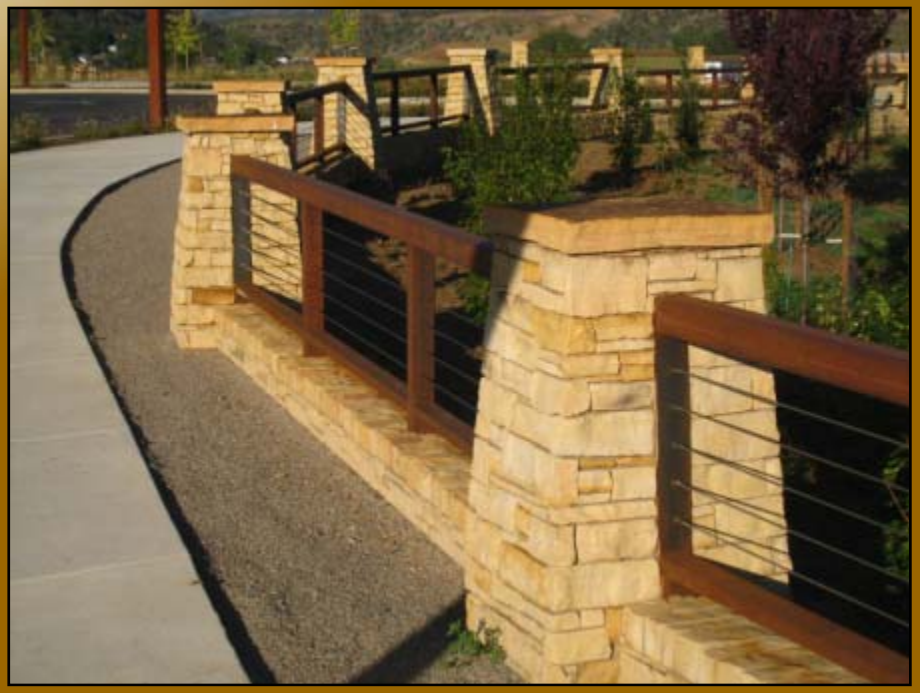
BRIDGE RAILINGS

- ✓ **Rural & Moderate Risk Areas ***
  - **AASHTO-based**
  - **42” for peds & 54” for bikes + equestrian**
  - **6” sphere to 27”, 8” sphere above 27”**

*** USFS Trail Bridge Catalogue**

BRIDGE RAILINGS

BRIDGE RAILINGS



BRIDGE RAILINGS

BRIDGE RAILINGS

- ✓ **Remote & Low Risk Areas ***
  - **OSHA-based**
  - **42” for peds & 54” for bikes + equestrian**
  - **15” between 2”x4” wood rails and 19” between steel rails**

*** USFS Trail Bridge Catalogue**

BRIDGE RAILINGS

BRIDGE LIGHTING

- ✓ **Functional = Safe**
- ✓ **Architectural**
- ✓ **Human scale**
- ✓ **Vandal resistant**
- ✓ **Maintenance**

LED use is revolutionizing lighting!!!

BRIDGE LIGHTING

BRIDGE LIGHTING

BRIDGE LIGHTING

BRIDGE LIGHTING

UNDERPASS VS. BRIDGE

CATEGORY	UNDERPASS	OVERPASS
Safety		
Convenience		
User Experience		
Resident Impact		
Environmental Impact		
Aesthetics		
Constructability		
Cost		

Legend	
Clear Advantage	
Neutral	
Clear Disadvantage	

COST CONSIDERATIONS

- ✓ Grading & Drainage
- ✓ Utility Relocation
- ✓ Traffic Control
- ✓ Retaining Walls
- ✓ Main Structure
- ✓ Secondary Structure
- ✓ Railings
- ✓ Street or River Repair
- ✓ Path Concrete
- ✓ Landscaping
- ✓ Right-of-way

Costs add up quickly.

Don't get caught short.

SELECTION BASICS

- ✓ Is crossing at-grade or separated
- ✓ Do you go over or under
- ✓ What is the best location
- ✓ How is it accessed
- ✓ Figure out the details
- ✓ Make sure you budget enough $$$

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