Willamette Water Supply
Our Reliable Water

Lessons Learned about Seismic Certification to Help Your Equipment Operate Post-Earthquake Event

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Jared Wagoner - Sundt
May 1, 2024

American Water Works Association
Pacific Northwest Section

Outline of Topics

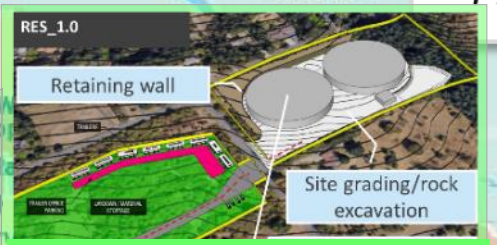
- WWSP Overview
- Nonstructural Components Background
- Seismic Certification Process
  - System Seismic Resiliency Elements
  - Pre-project Planning
  - Design Phase
  - Procurement Phase
  - Construction Phase

Willamette Water Supply Program

***Mission Statement: Provide a cost-effective, reliable and resilient water supply system** by July 2026, that benefits current and future generations of the communities we serve and supports a vibrant local economy.*

30+ Miles of 66” & 48” Welded Steel Pipelines

More than 130,000 LF (~25 miles) of 66-inch and 48-inch waterline installed to date



15 MG Storage Tanks

New Water Treatment Plant

It’s important to think about this as a “system” when considering seismic resilience

For seismic certification it’s about the facilities

Modified River Intake

Image from the Regional Water Providers Consortium

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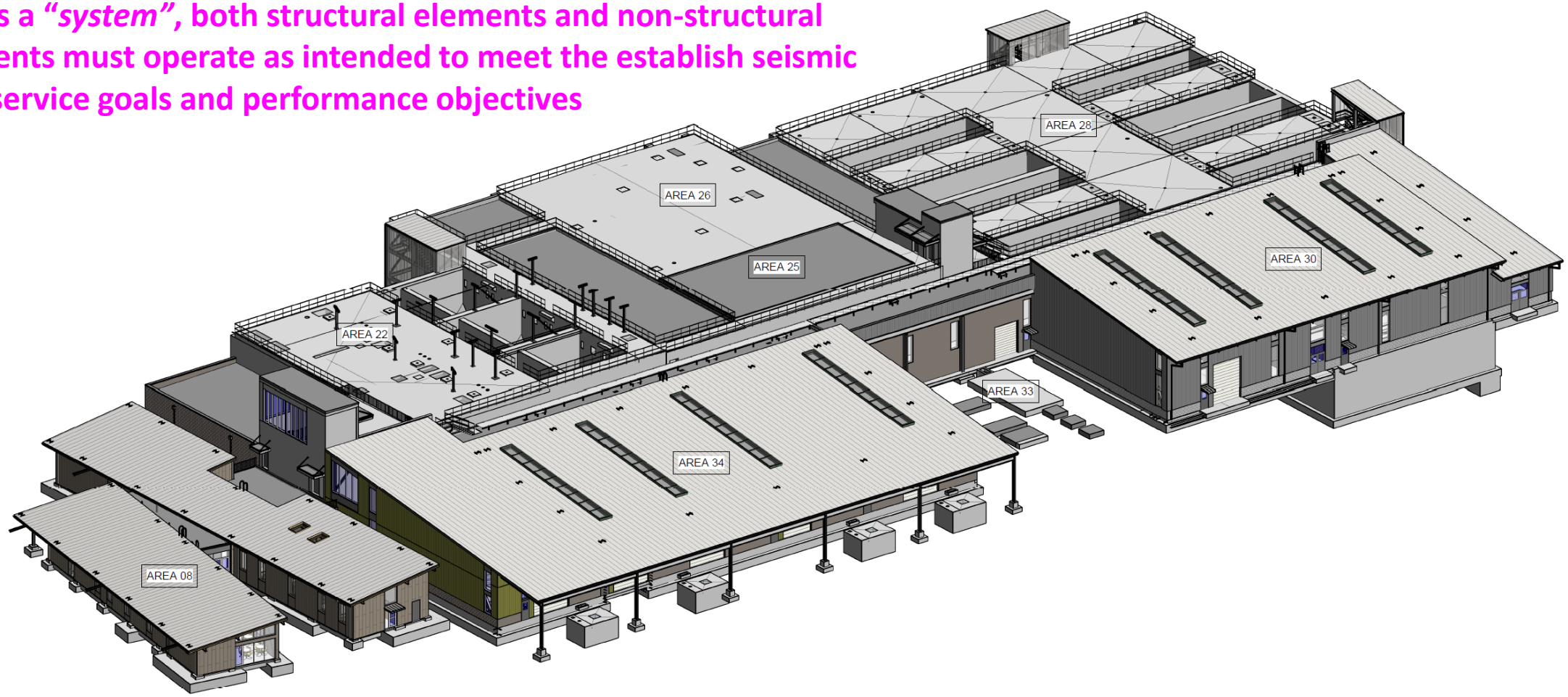
Structural & Nonstructural Components are Important

Since it is a "*system*", both structural elements and non-structural components must operate as intended to meet the establish seismic level of service goals and performance objectives



WTP Isometric

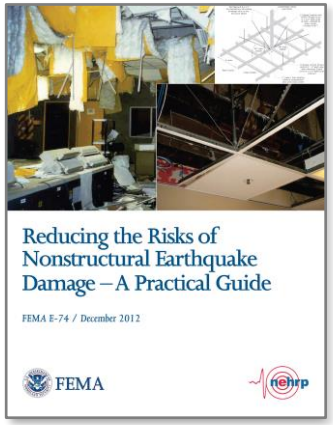
What Are Nonstructural Components

Nonstructural elements can be divided into three broad categories according to their service and function, namely:

1. Architectural elements, such as infill and partition walls, curtain walls, ceiling systems, and architectural ornamentations;
2. Mechanical, electrical, and plumbing elements for example pumps, chillers, fans, air-handling units, motor control centers, electrical cabinets, distribution panels, transformers, and piping;
3. Furniture, fixtures and equipment, and contents such as shelving and bookcases, industrial storage racks, medical records, computer and desktop equipment, wall- and ceiling-mounted TVs and monitors, industrial chemicals and hazardous substances, historical and cultural objects [FEMA E-74 in Zito et al., 2022].

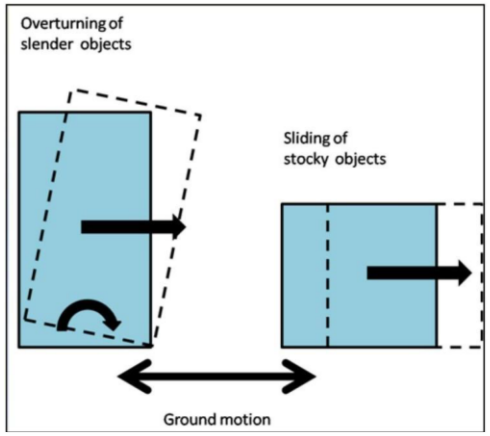
Focus of this presentation

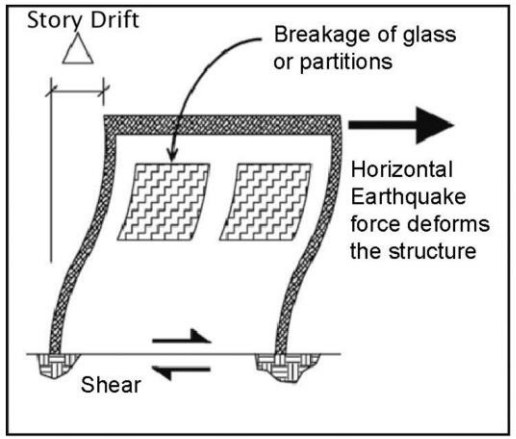
How Nonstructural Components are Damaged



(Source: FEMA E-74)

1. Inertial forces "or shaking effects cause sliding, rocking, or overturning"

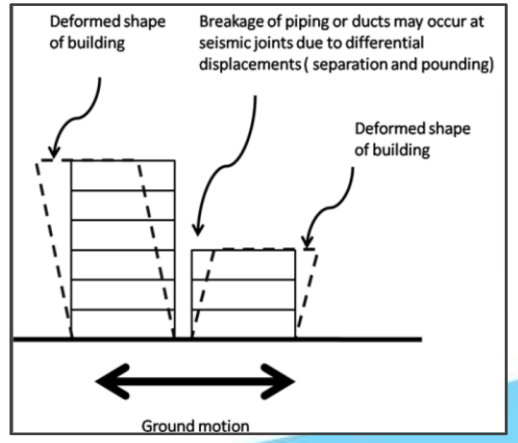




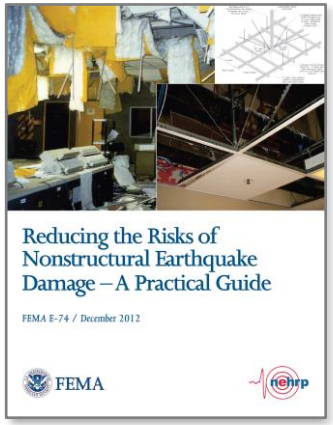
2. Building deformations "damage interconnected nonstructural components"

"Nonstructural element damage may result in human losses and casualties, costly property damage to buildings and their contents, and functioning disruptions." (Zito et al, 2022)

3. Building separation "or pounding between separate structures damage nonstructural components crossing between them"



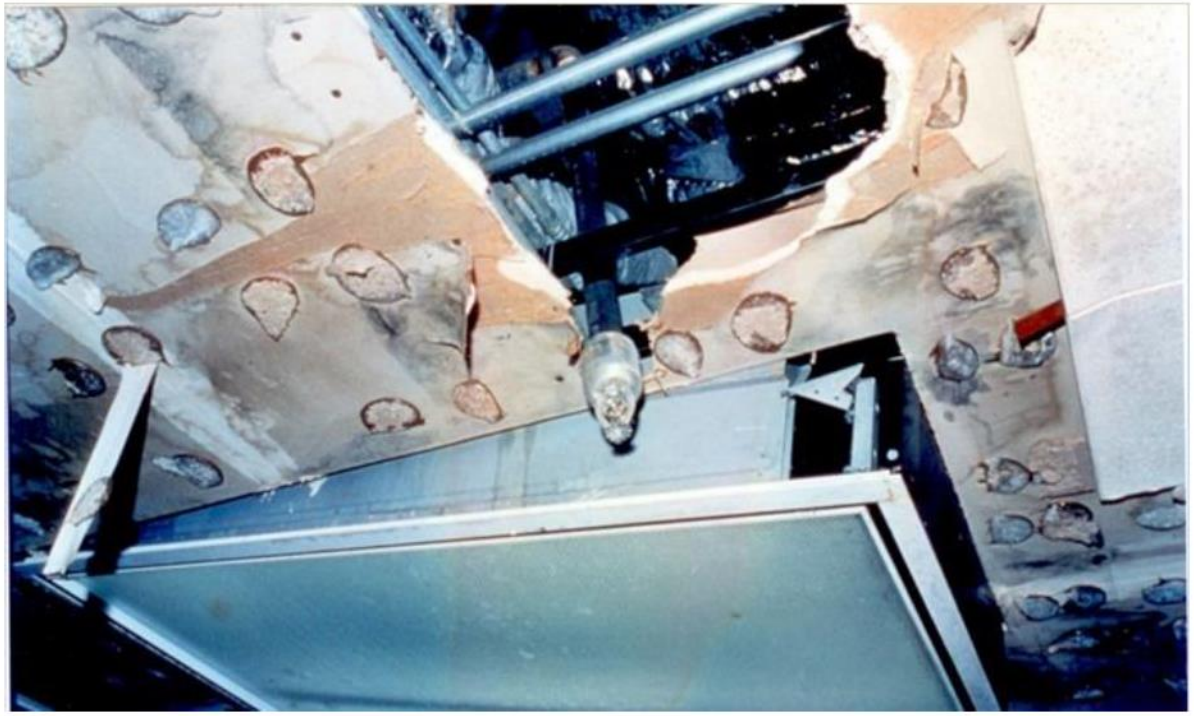
Example of Nonstructural Component Damage



(Source: FEMA E-74)

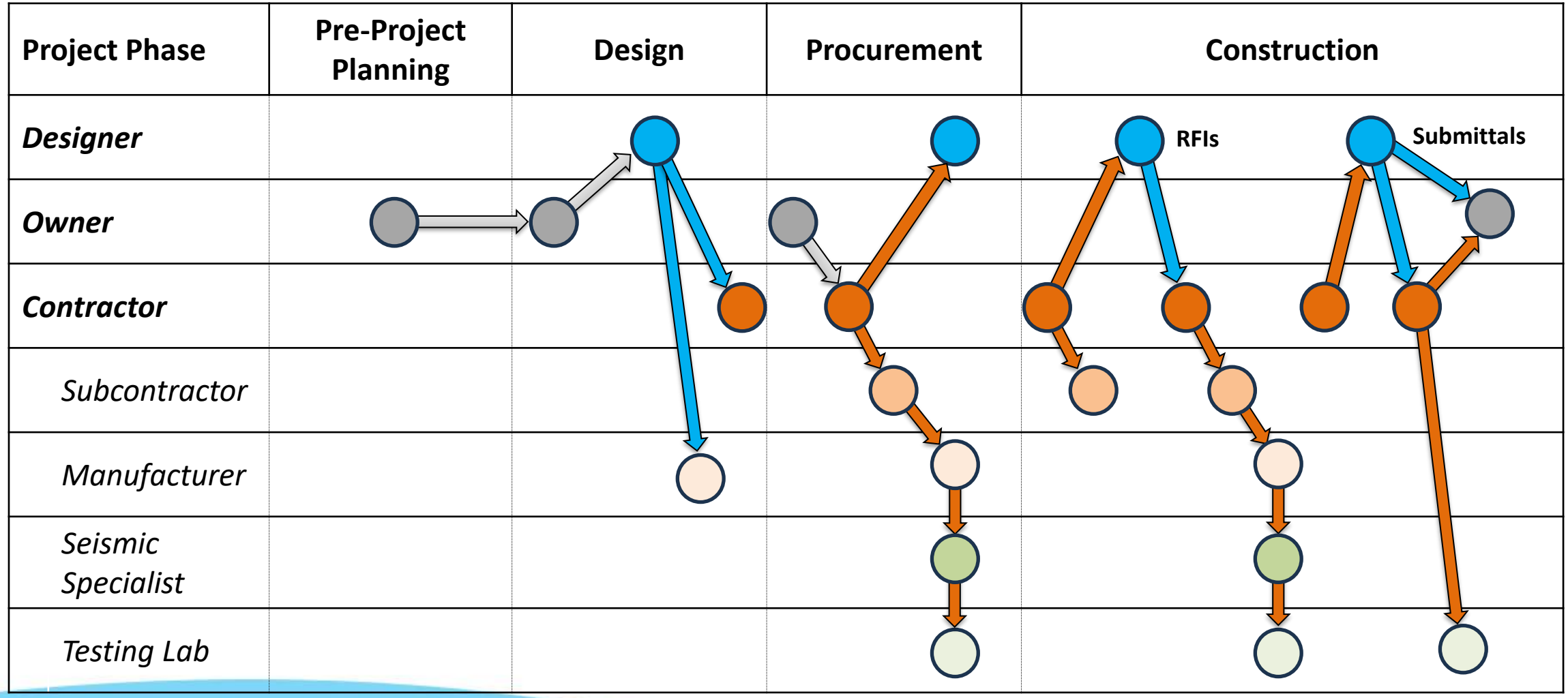
- Interaction "between adjacent nonstructural components… [can] cause damage"

"During the 1994 Northridge Earthquake, nonstructural damage caused temporary closure, evacuation, or patient transfer at ten essential hospital facilities. These hospitals generally had little or no structural damage were rendered temporarily inoperable, primarily because of water damage"

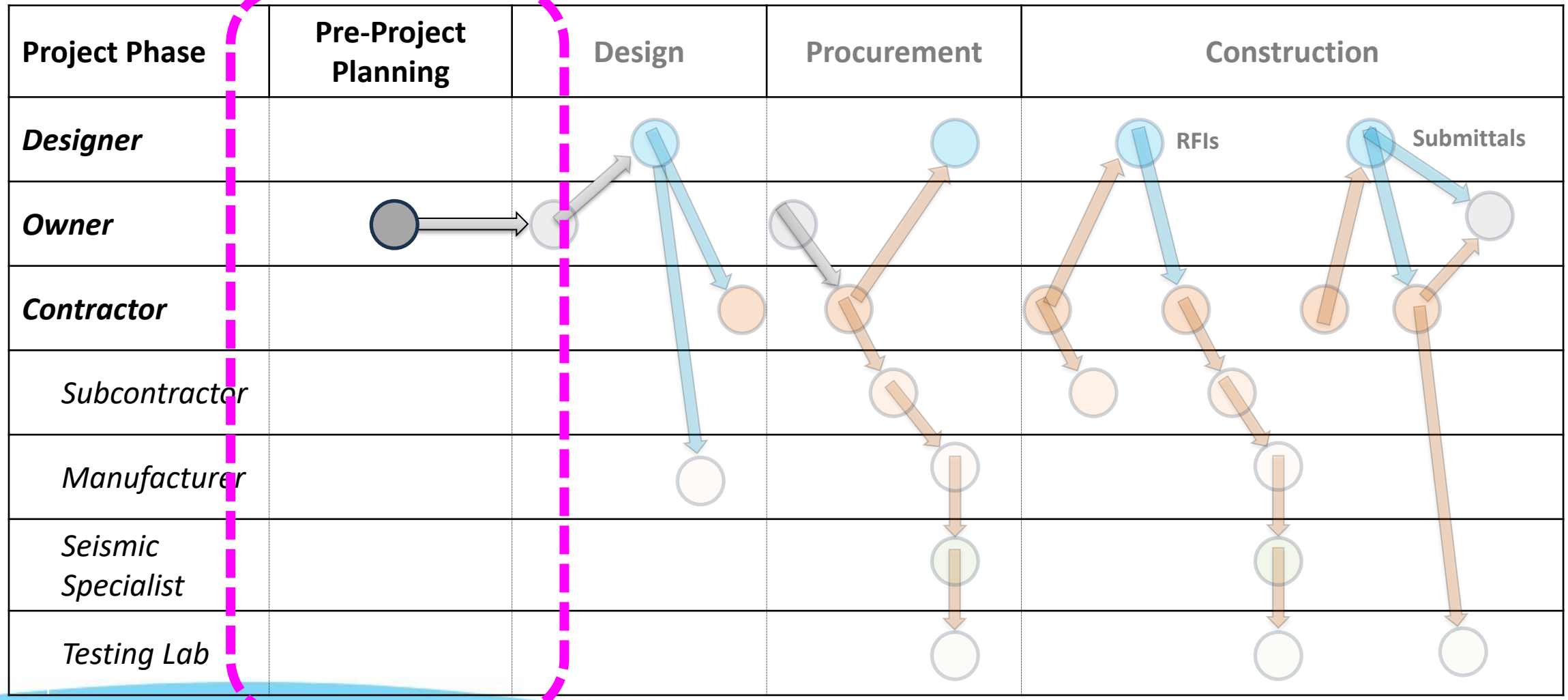


Broken sprinkler pipe at Olive View Hospital in Sylmar, California as a result of the 199t Northridge Earthquake (Source: FEMA E-74)

Overall Process for Seismic Certification



Pre-Project Planning



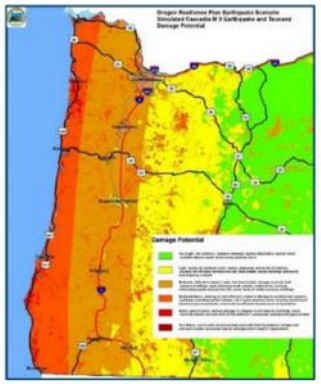
Pre-Project Planning

Policy Decisions:

- Level of service goals
  - Including do you want it be designed like an “essential facility” (e.g. like a hospital and have it be operable after the earthquake is done)

Establish Level of Service Goals

Level of Service Goals followed ***Oregon Resilience Plan*** Guidance (for Backbone Systems)



System Component	Capacity	Timing
Pipeline	80 – 90%	0 – 24 hours
Reservoirs	80 – 90%	0 – 24 hours
Turnouts	80 – 90%	0 – 24 hours
Raw Water Facilities	25% 50%	24 hours 48 hours
Treatment Plant	25% 50%	24 hours 48 hours

Performance Goals

Pressure Integrity

Operational Performance

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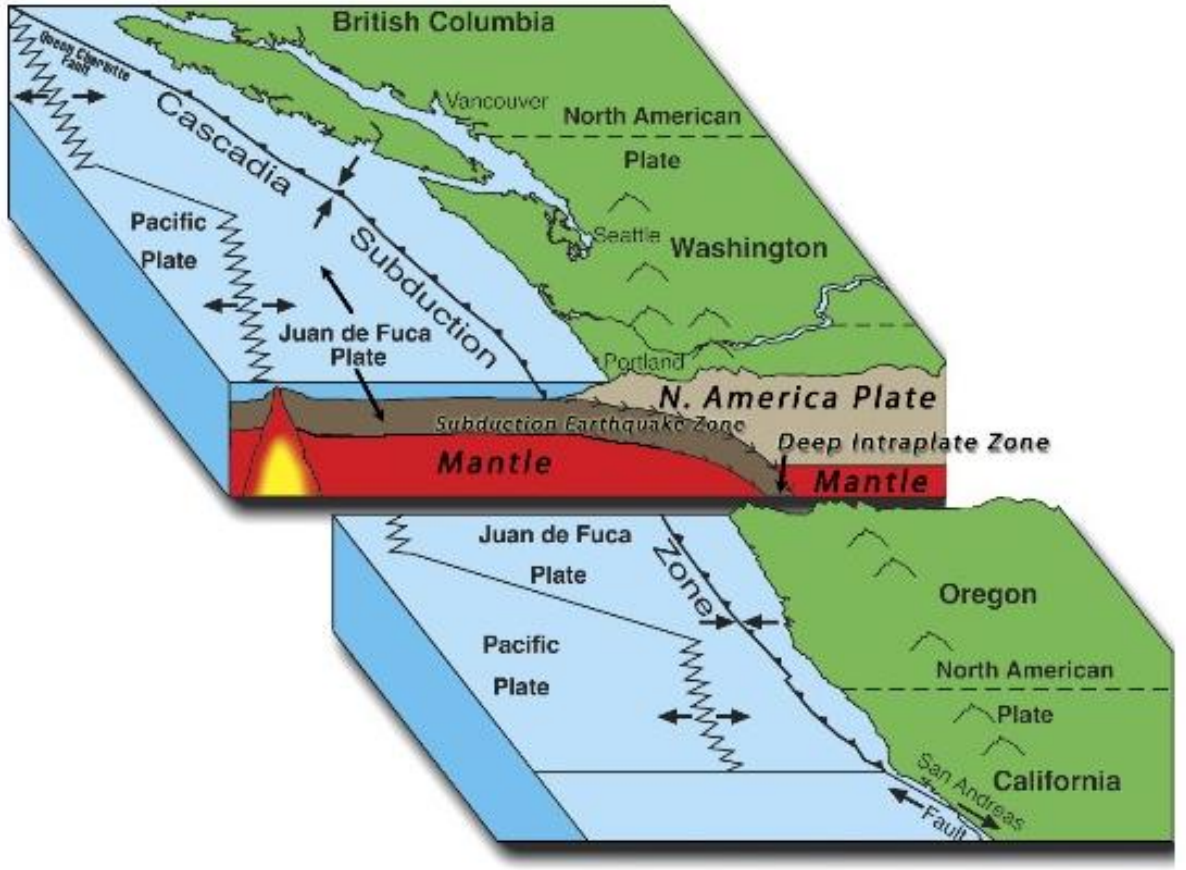
Pre-Project Planning

Policy Decisions:

- Design earthquake
  1. Per code *use 2/3 of MCE*, maximum considered earthquake (~500 yr. EQ) , or
  2. Use *full MCE* due to criticality of infrastructure to the community it serves (~2,500 yr. EQ)

Approach adopted by WWSP and endorsed by its leadership



Source: Oregon Office of Emergency Management

Pre-Project Planning

Decisions around procurement and project execution:

- Design consultant (DC) – considerations include:
  - Qualifications based selection
  - Identify key tasks in scope (helping owner to identify facility design classification, e.g. Risk Category IV, seismic importance factor)
  - Plan for seismic workshops
  - Require DC to identify critical equipment
  - Identify seismic task lead

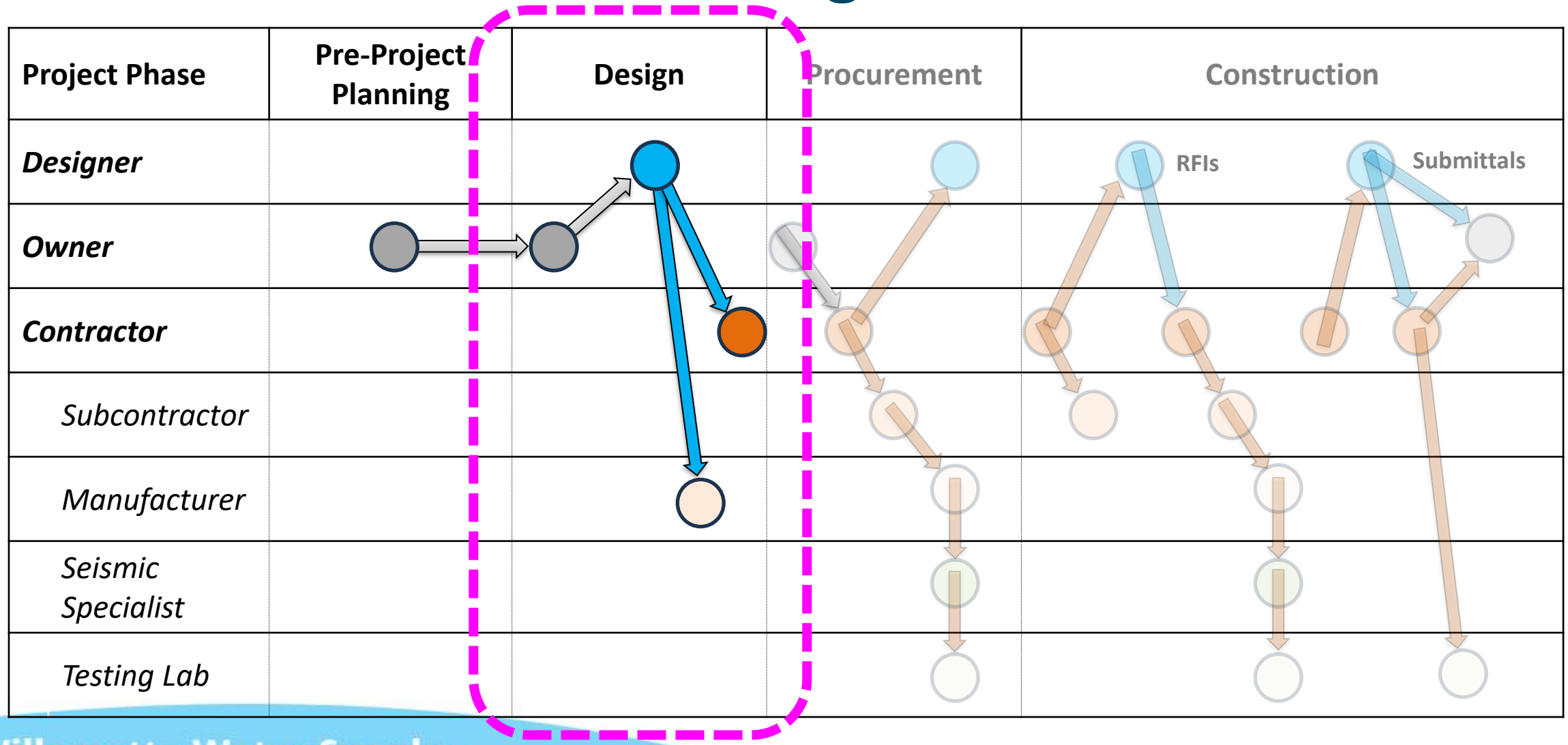
This all has to go in the scope for the DC before you start the design consultant selection process

Pre-Project Planning

Decisions around procurement and project execution:

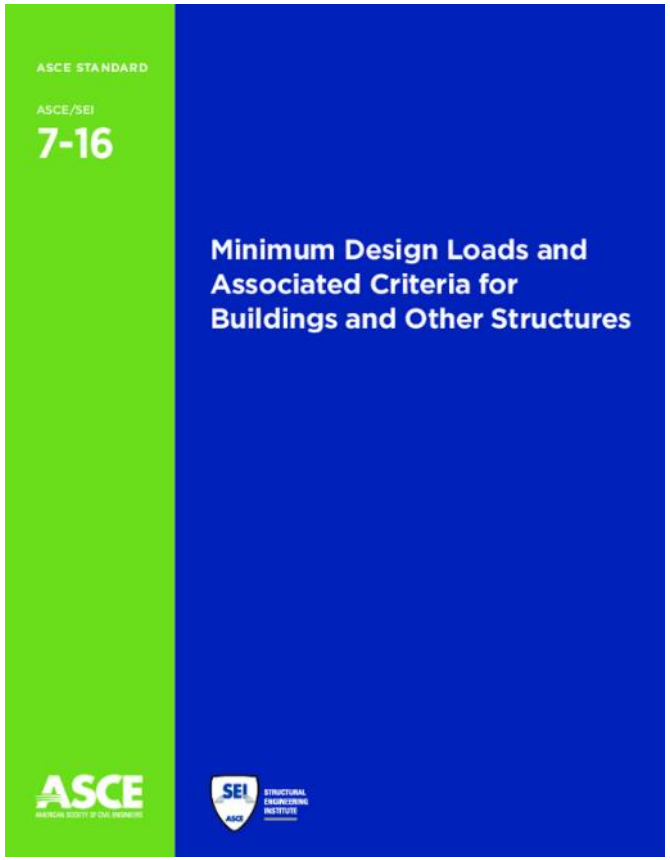
- CM/GC Alternative Delivery Utilized – considerations include:
  - Qualifications based selection
  - Complexity of work supports selection of alternate delivery
  - Demonstration of some level of understanding of Owner's goals and objectives for seismic resiliency
  - Looking for someone who can be a good team player with the Owner because some of this you have to "figure out as you go"

Design


Project Phase
Pre-Project Planning
Design
Procurement
Construction
Designer
Owner
Contractor
Subcontractor
Manufacturer
Seismic Specialist
Testing Lab
RFIs
Submittals

Designer Completes Spec Requirements

- Determine site specific ground motion data
  - Approx. 1+ g requirement (varies by site)
- Approval paths per ASCE 7-16 (Chapter 13)
  - Shake Table Tests
  - Analysis
  - “Ruggedness”



DC Establishes Seismic Testing Requirements

- Based on Site Specific Site Data:
  - S_{DS} is the design spectral response acceleration parameter at short periods. It is the acceleration value derived for the site used to go into the AC156 equations that establish the shake table test motions (along with other installation specific characteristics)

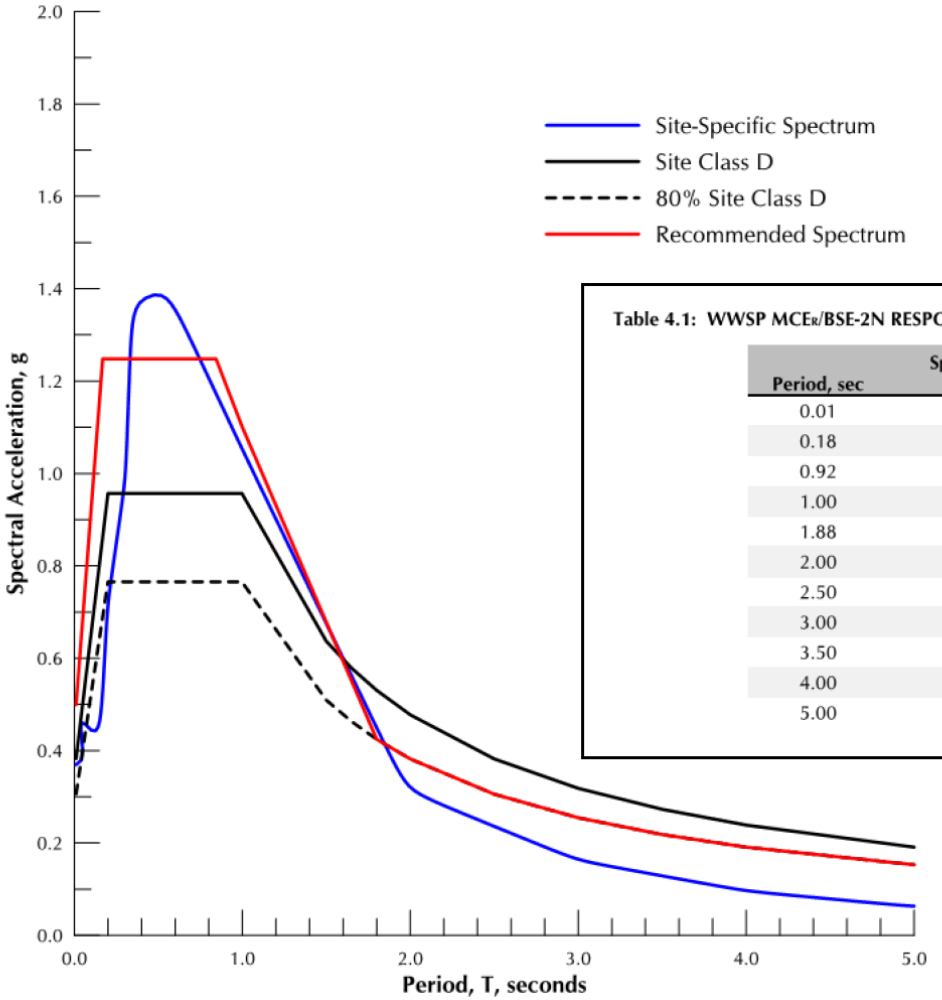


Table 4.1: WWSP MCE$_R$/BSE-2N RESPONSE SPECTRAL VALUES, 5% DAMPING

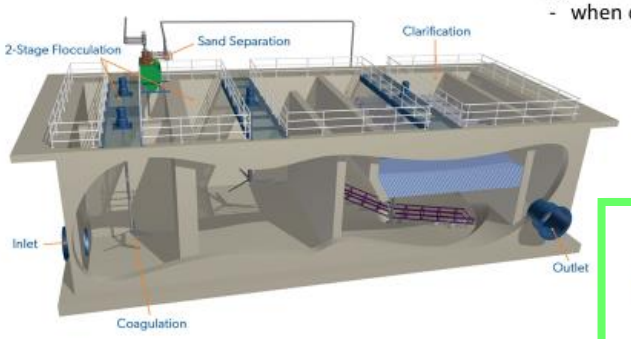
Period, sec	Spectral Acceleration Values, g[1]
0.01	0.51
0.18	1.29
0.92	1.29
1.00	1.21
1.88	0.42
2.00	0.38
2.50	0.31
3.00	0.25
3.50	0.22
4.00	0.19
5.00	0.15

Raw Water Facilities Seismic Site Data, S_{DS} = 1.29 g

Water Treatment Plant

Ballasted Flocculation

- Physical-chemical process
- Turbidity/particle removal
- Algal toxins
  - when contained in intact cells



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Classified as *"Critical"* Systems (seismic certification required)

Ozonation

- Chemical process
- Primary role: break down complex organics
  - Taste and odor
  - Algal toxins
  - Emerging contaminants (pharmaceuticals)
- Secondary role: disinfection (cyst-type organisms)

Liquid Oxygen Tank

Ozone Generator

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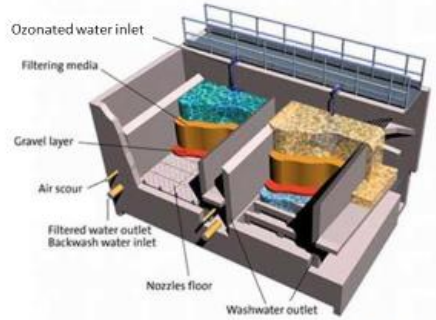
Classified as *"Semi-Critical"* Systems (impractical to get seismic certification/not needed for primary water quality needs)

Filtration

- Physical and biological process
- Turbidity/particle removal
- Simple organics removal (biofiltration)
- Complex organics removal (activated carbon)



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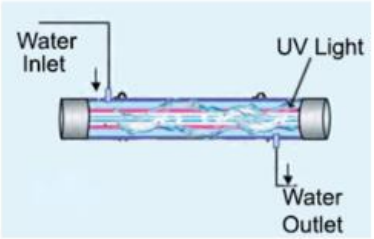
UV Disinfection

- Physical process
- *Giardia* and *Cryptosporidium* inactivation
- Emerging contaminant destruction when combined with hydrogen peroxide



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13

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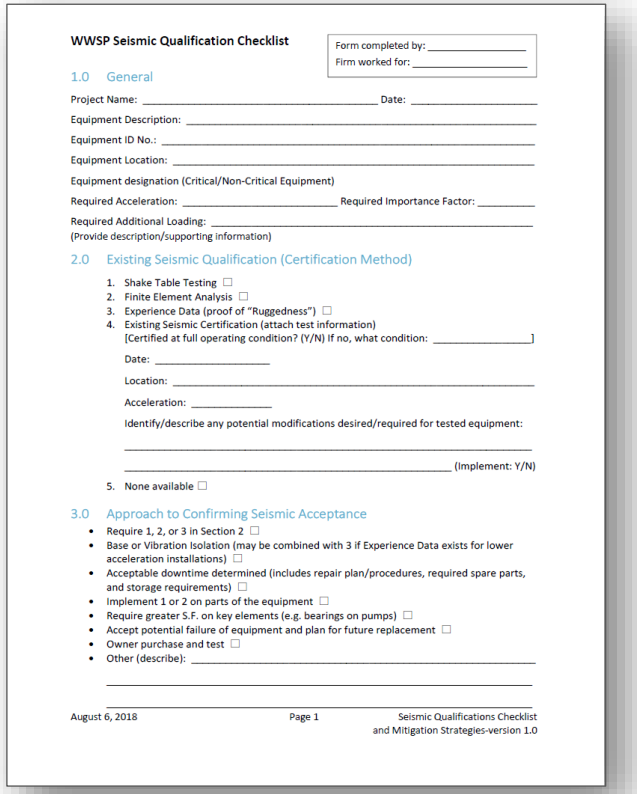
Designer Needs to “Work with the Industry”

Some of their work includes:

- Figuring out what’s currently available from the industry related to seismic certification
- Making sure the manufacturers understand and can deliver on the requirements
- Attending “Seismic Workshops” with the Owner team to talk through things

WWSP Seismic Certification Checklist:



WWSP Seismic Qualification Checklist

Form completed by: _____
Firm worked for: _____

1.0 General

Project Name: _____ Date: _____
Equipment Description: _____
Equipment ID No.: _____
Equipment Location: _____
Equipment designation (Critical/Non-Critical Equipment)
Required Acceleration: _____ Required Importance Factor: _____
Required Additional Loading: _____
(Provide description/supporting information)

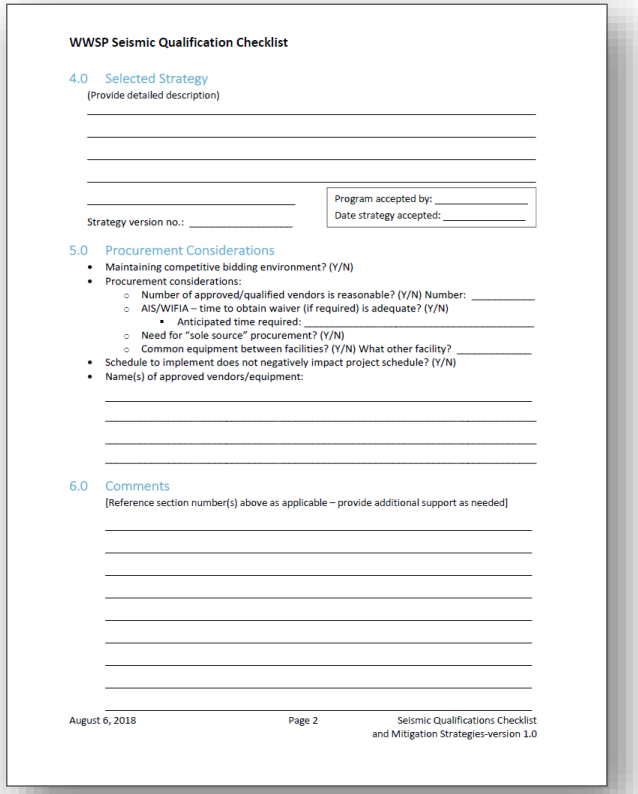
2.0 Existing Seismic Qualification (Certification Method)

1. Shake Table Testing ☐
2. Finite Element Analysis ☐
3. Experience Data (proof of “Ruggedness”) ☐
4. Existing Seismic Certification (attach test information)
   [Certified at full operating condition? (Y/N) If no, what condition: _____]
   Date: _____
   Location: _____
   Acceleration: _____
   Identify/describe any potential modifications desired/required for tested equipment:
   _____
   _____ (Implement: Y/N)
5. None available ☐

3.0 Approach to Confirming Seismic Acceptance

- Require 1, 2, or 3 in Section 2 ☐
- Base or Vibration Isolation (may be combined with 3 if Experience Data exists for lower acceleration installations) ☐
- Acceptable downtime determined (includes repair plan/procedures, required spare parts, and storage requirements) ☐
- Implement 1 or 2 on parts of the equipment ☐
- Require greater S.F. on key elements (e.g. bearings on pumps) ☐
- Accept potential failure of equipment and plan for future replacement ☐
- Owner purchase and test ☐
- Other (describe): _____

August 6, 2018 Page 1 Seismic Qualifications Checklist and Mitigation Strategies-version 1.0



WWSP Seismic Qualification Checklist

4.0 Selected Strategy

(Provide detailed description)

_____

Program accepted by: _____
Date strategy accepted: _____

Strategy version no.: _____

5.0 Procurement Considerations

- Maintaining competitive bidding environment? (Y/N)
- Procurement considerations:
  - Number of approved/qualified vendors is reasonable? (Y/N) Number: _____
  - AIS/WIFIA – time to obtain waiver (if required) is adequate? (Y/N)
    - Anticipated time required: _____
  - Need for “sole source” procurement? (Y/N)
  - Common equipment between facilities? (Y/N) What other facility? _____
- Schedule to implement does not negatively impact project schedule? (Y/N)
- Name(s) of approved vendors/equipment:

_____

6.0 Comments

[Reference section number(s) above as applicable – provide additional support as needed]

_____

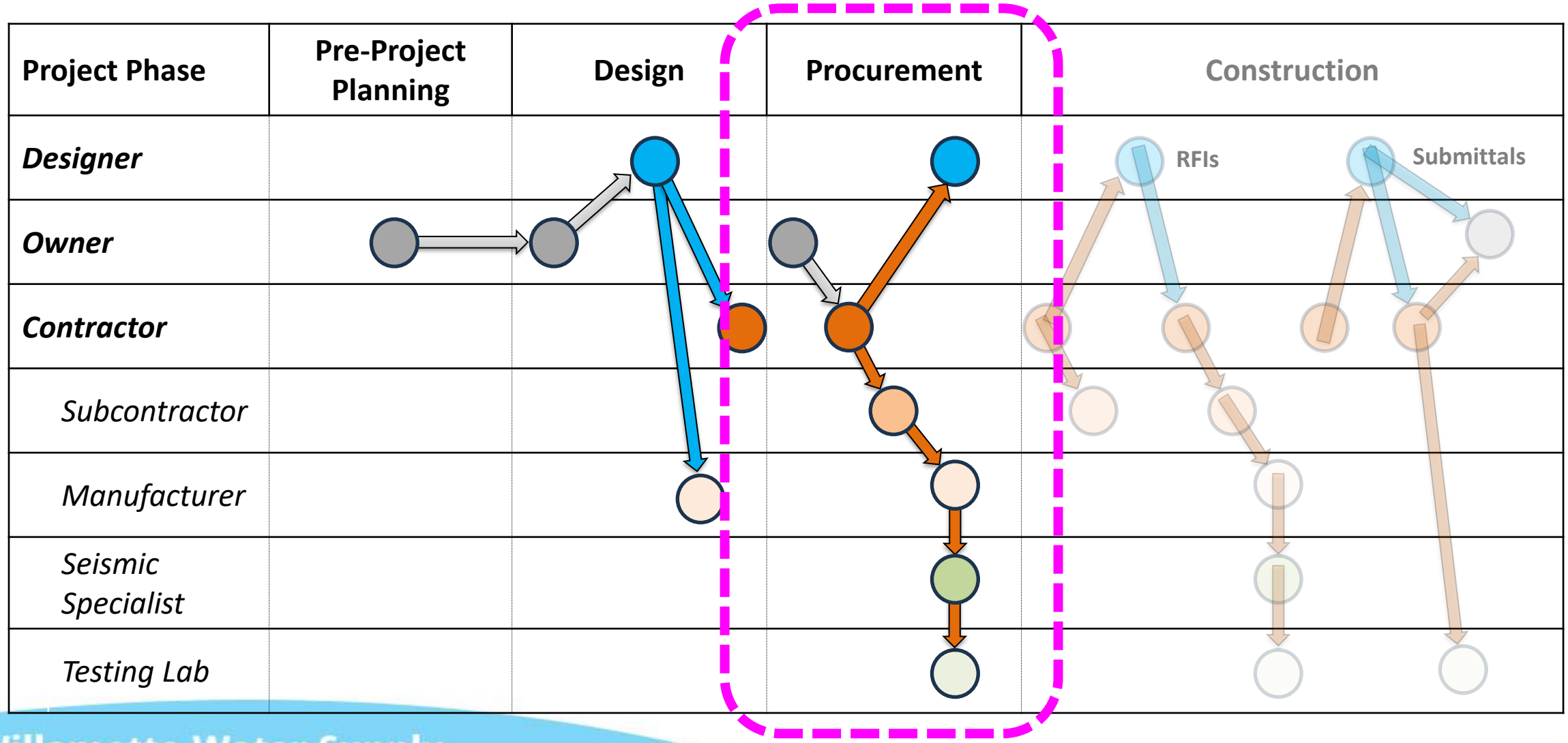
August 6, 2018 Page 2 Seismic Qualifications Checklist and Mitigation Strategies-version 1.0

Design

At the end of design, everybody gets it:

- Design Consultant
- CM/GC Contractor
- Vendors
- Internal Staff

Procurement

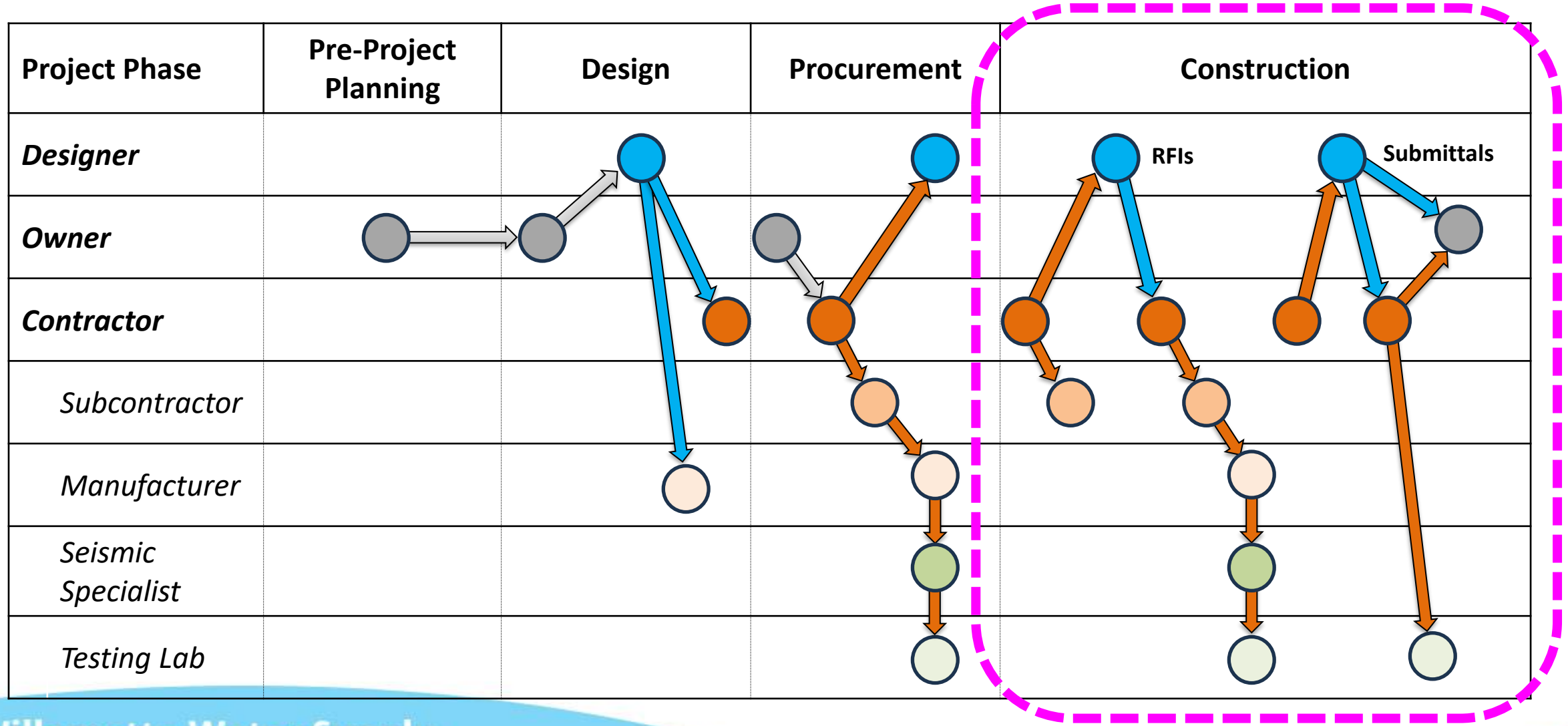


Procurement

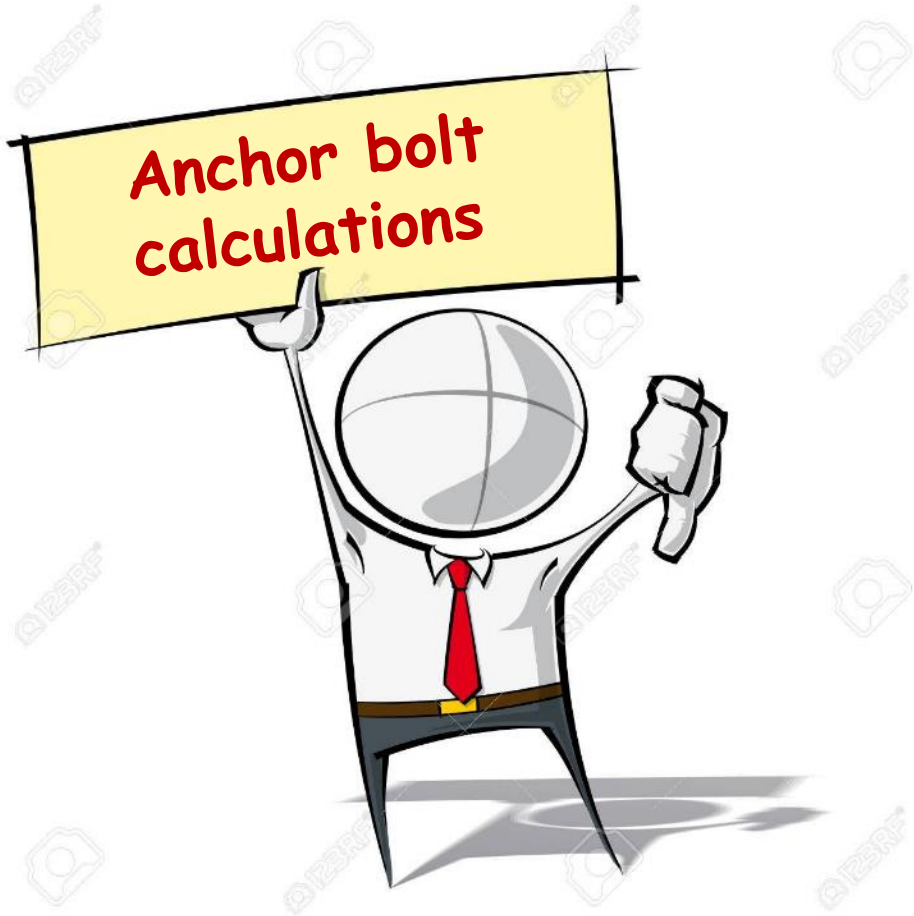
Contractor Outreach (RWF Example):

- Extensive outreach effort
  - Direct bidder contact
  - Focus on critical packages
  - Pre-bid outreach workshop
  - Pre-bid workshop and site tour
- Bidder questions addressed
- Best value utilized
  - WWSP developed evaluation criteria
  - Prequalification required (in cases)
- WWSP administered key procurement activities
- No bid protest occurred
- Open book approach utilized

Construction



Construction



- Communications between multiple subcontractors/ vendors/manufacturers is complicated:
  - Seismic calculations for anchor bolts is not what we mean for “seismic certification”

Construction

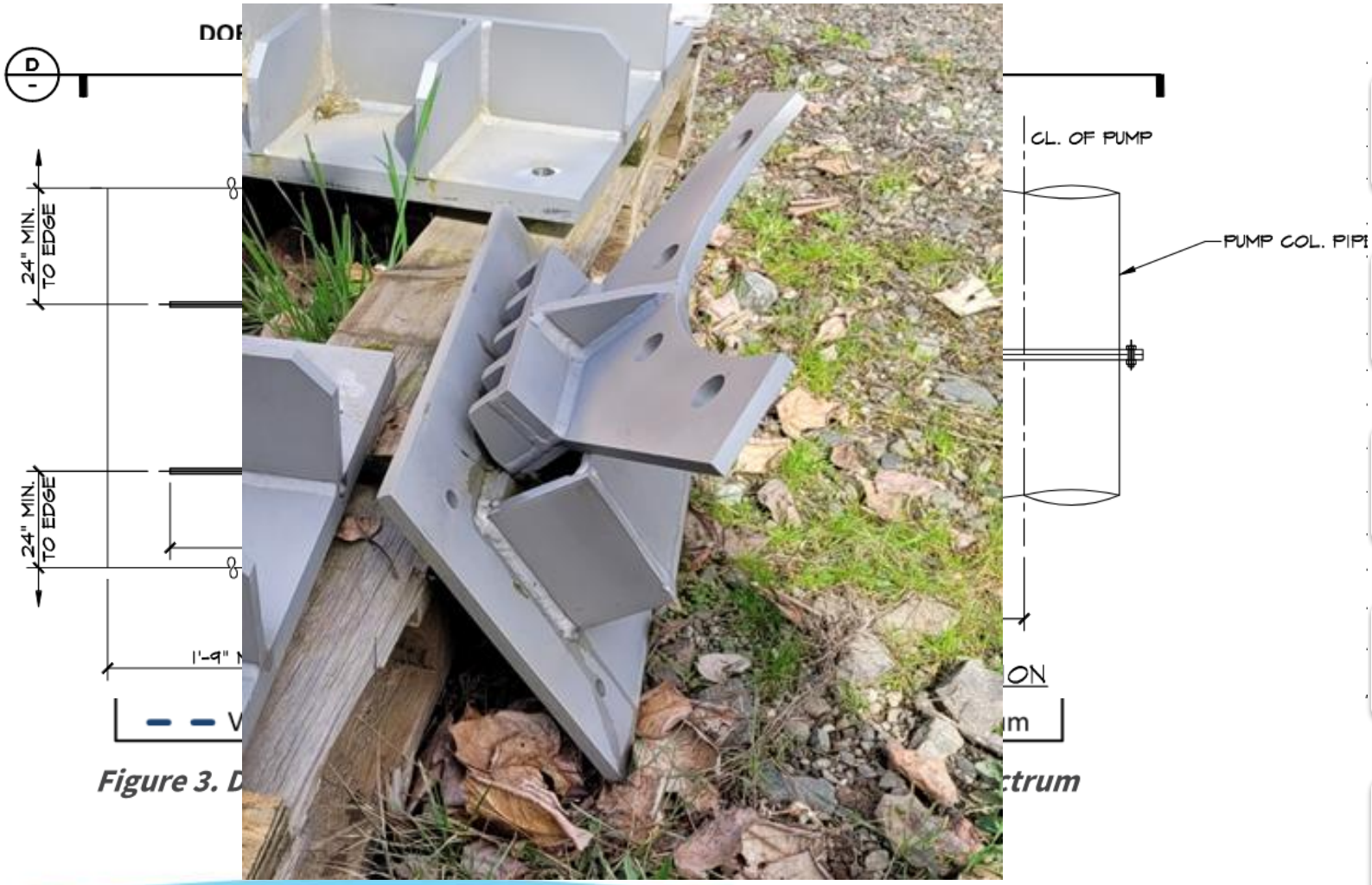


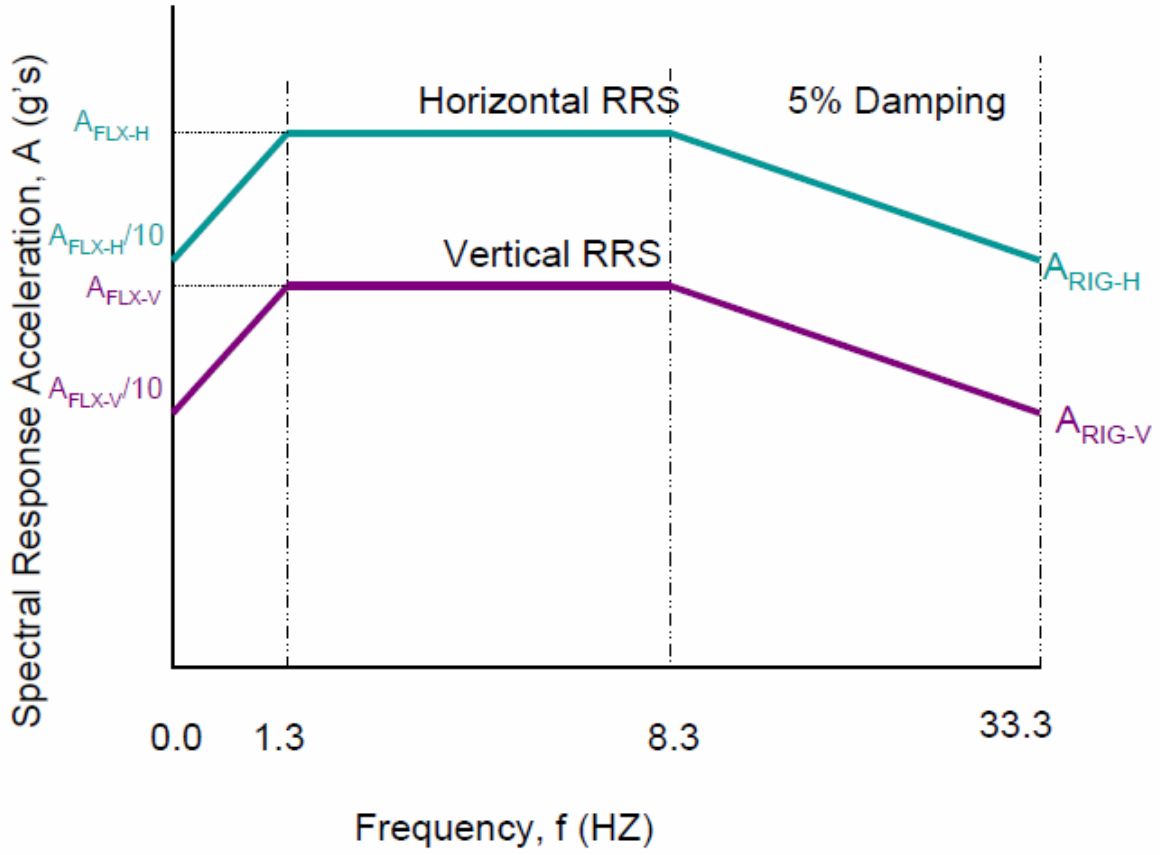
Figure 3. D ctrum

- Baseline Equipment Submittal
- Preferred Seismic Qualification Method
- Preliminary Seismic Qualification
- Revisions to Equipment
- Final Equipment/Seismic Certification

Shake Table Testing

Testing Standard AC156,
"Acceptance Criteria for Seismic Certification by Shake-Table Testing of Nonstructural Components"

- Resonance frequency test in X-Y-Z directions
- Seismic simulation test using project S_{DS} values
- Can be tested for z/H = 0 (ground) or z/H = 1 (roof) locations

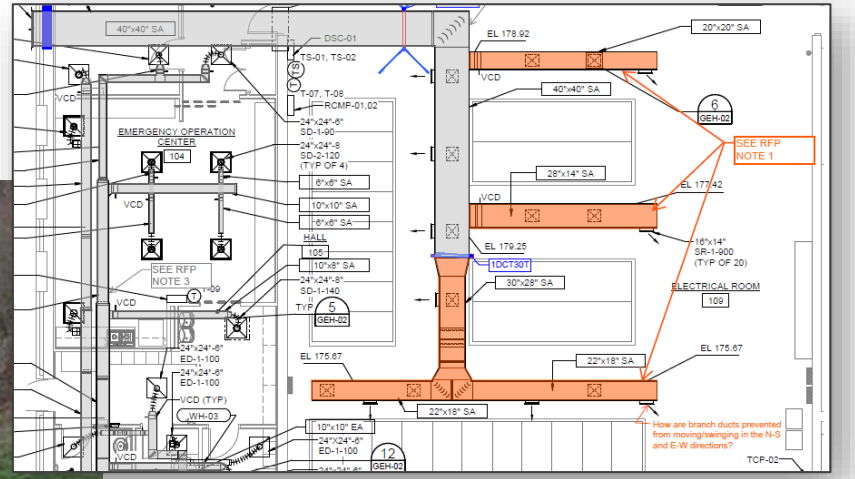


Required Response Spectrum, Normalized for the Component
(Source: AC156)

The Things that Make You Ask, “Really?”

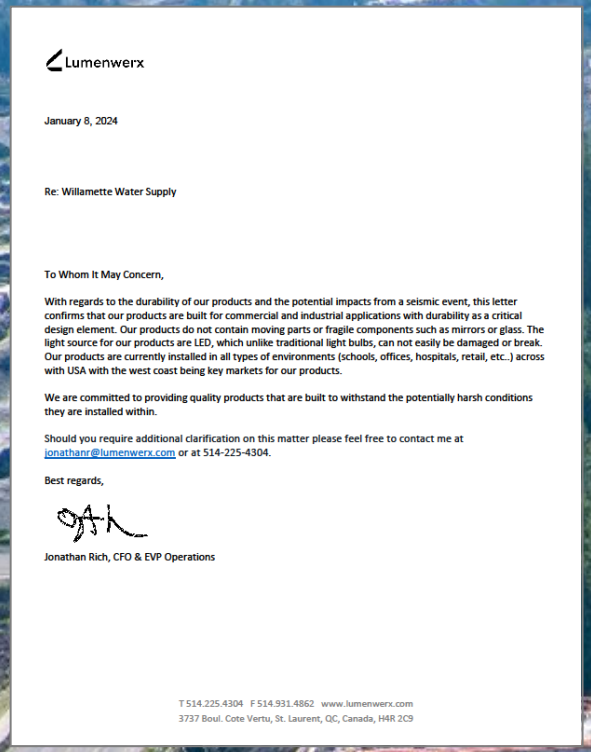
Raw Water Facilities

Ductwork – Bracing Calculations and Supports



Water Treatment Plant

- Critical Lighting
  - Letters from vendors related to their use in high seismic areas
  - Shake table testing on limited set of products



Lumenwerx

January 8, 2024

Re: Willamette Water Supply

To Whom It May Concern,

With regards to the durability of our products and the potential impacts from a seismic event, this letter confirms that our products are built for commercial and industrial applications with durability as a critical design element. Our products do not contain moving parts or fragile components such as mirrors or glass. The light source for our products are LED, which unlike traditional light bulbs, can not easily be damaged or break. Our products are currently installed in all types of environments (schools, offices, hospitals, retail, etc..) across with USA with the west coast being key markets for our products.

We are committed to providing quality products that are built to withstand the potentially harsh conditions they are installed within.

Should you require additional clarification on this matter please feel free to contact me at jonathanr@lumenwerx.com or at 514-225-4304.

Best regards,

Jonathan Rich, CFO & EVP Operations

T 514.225.4304 F 514.931.4862 www.lumenwerx.com
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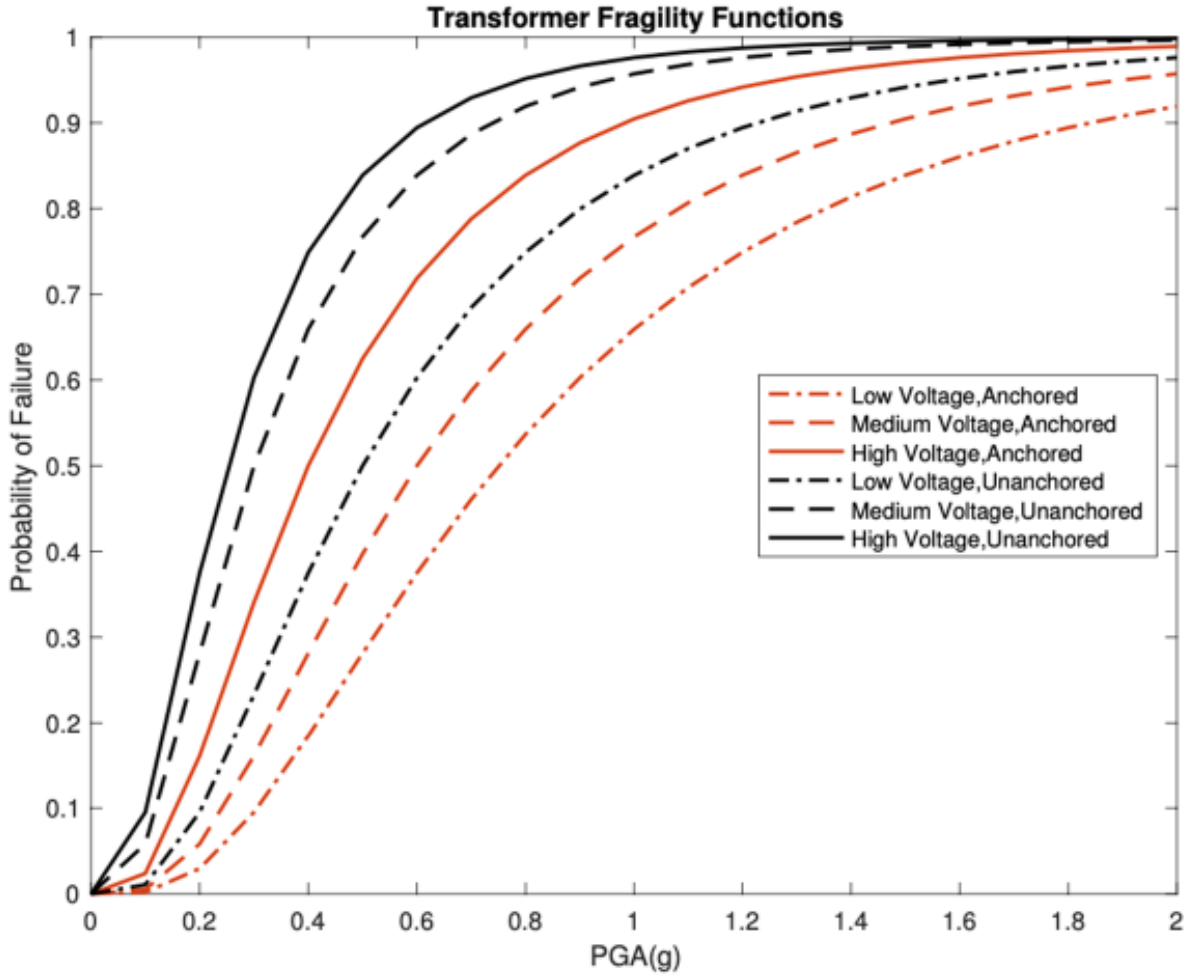
Transformers Can be Challenging

Some of the Challenges:

- Different types of transformers that vary in size & complexity
- Have elements that can be very vulnerable to high ground motions
- Ongoing Work by Others:
  - IEEE 693 *Recommended Practice for Seismic Design of Substations*
  - Oregon State University Research



Transformers Can be Challenging

BPA Solutions Can Involve Base Isolation

(Source: BPA Presentation "Cascadia Substation Zone Lifeline Resiliency" May 8, 2023)

(Source: BPA Transformer and Reactor Base Isolation STD-DS-000061)

Water Treatment Plant

- Large generator switchgear:
  - Held up by a supply chain issue with a fourth-tier sub/supplier

Start the process as early as you can. Besides the long process to get seismic and other submittals completed so the equipment can be released for fabrication, other issues can impact delivery schedules

Seismic Certification Conclusions

- At the end of the day, you just hit the “easy” button, right?
- **No, it takes a lot of work:**
  - Owners to establish project goals
  - Designers to set up the documents properly and work with the manufacturers to understand what’s possible
  - Contractor to communicate with subcontractors and vendors regarding what’s expected and then follow-through during construction

Wrong!

Questions

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