STANDARD MITIGATION PLAN "A" - BASIC REPAIR

Basic repair involves visual inspection of concrete followed by mechanical removal and replacement of unacceptable concrete from anomalies accessed from the ground surface or by excavation. Mechanical removal is performed using a chipping gun or similar means under the observation and direction of the inspector.

A. Excavation

1. Excavate alongside of the CIDH pile in the vicinity of the designated inspection tube(s) to a depth of one foot below the identified anomaly to provide access. Shoring plans, confined space plans, and provisions for replacement of earthen materials disturbed by excavation shall be submitted as appropriate.

B. Removal of Deleterious Material

1. After excavation and exposure of the anomaly, all visually deleterious or questionable material will be removed. Mechanical removal will "chase" all inclusions or compromised concrete until competent concrete is encountered.

2. If the surface of the CIDH pile shows apparently competent concrete, the identified anomaly will be hammer tested or hand-chipped one inch to demonstrate that the surface manifestation is consistent with concrete below the pile surface.

C. Additional Inspection

1. At contractor's option, a minimum 3-inch diameter core sample shall be obtained from the anomalous zone if required for additional visual inspection and/or strength testing. The core shall extend to the center of the anomalous zone or as approved by Caltrans. Strength testing shall be performed in accordance with Caltrans standard testing procedures.

2. If visual inspection or the results of compressive strength testing indicate that the concrete is not acceptable, the unacceptable concrete shall be mechanically removed to the extent determined by the inspector.

D. Verification of Results by Engineer

1. After the Contractor has removed all material that is visibly compromised or questionable, the Engineer will visually and physically inspect the effectiveness of the removal operation. If the concrete is deemed acceptable, the removal will be terminated and approved. If additional questionable material is identified, the Contractor shall remove this material and request that the Engineer reinspect.

E. Replacement

1. After removal of unacceptable concrete and questionable material, forms shall be constructed as necessary, and the specified concrete mix shall be placed in the repair area.

2. After the concrete has cured, forms shall be removed.

F. Restoration of Earthen Materials

1. Earthen materials shall be replaced as approved by Caltrans. Where not otherwise designated, earthen materials shall be replaced using the excavated soil and compacted to a relative density that approximates the undisturbed, in-situ density of adjacent earthen materials. Two-sack sand slurry may be used if the Engineer of Record indicates that this will not adversely affect the lateral stiffness of the pile.

G. Reporting

1. Upon completion of the mitigation procedure, a mitigation report shall be submitted stating what repair work was performed and whether the repair work conformed with the mitigation plan. Any deviations from the mitigation plan must be stated in the report.

STANDARD MITIGATION PLAN "B" - GROUTING REPAIR

A. Inspection Tube Removal and High-Pressure Washing

1. The PVC inspection tube shall be cut with high pressure water for the entire elevation range of the anomaly, extending from two feet below the anomaly to two feet above the anomaly. The anomaly shall be pressure washed with the high pressure water directed laterally against the side of the hole and rotated as it is slowly withdrawn. Water jetting shall begin from the lowest anomalous region and proceed upward. Only one anomaly shall be washed and grouted at a time, except where approved in writing by the Engineer.

2. The Contractor shall make provisions to ensure that the required cutting pressure is achieved at the anomaly depth and that the PVC tube is entirely removed at the repair location. Water pressures typically range from 9,000 to 15,000 psi at a rate of 10 to 15 gpm. Several hundred psi may be lost in the line as a result of pump and line configuration. Lower pressures may be used at contractor's discretion once PVC inspection tube is removed.

3. Washing will continue until no further solids are observed emanating from the inspection tube and the return flush water is clear, except in the case of erosion of native material, as noted in paragraph 6 below.

4. The Contractor shall monitor the solids content in the wash return water by periodically straining solids out of the effluent.

5. The Contractor shall keep a log of unanticipated communication between holes, water color, type of solids, and estimated solids content.

6. The pressure washing procedure shall be monitored to reduce the chance of disturbance of the formation around the pile while attempting to remove loose sediment and contaminated concrete. Washing shall be discontinued if evidence of significant erosion of native material is observed.

B. Flushing

1. Flushing (high-volume, low-pressure washing) shall be performed if there is significant communication between inspection tubes. The

purpose of flushing is to remove loose material after pressure washing and prior to grouting or down-hole camera observation.

2. Water shall be pumped into an inspection tube and be allowed to return from another tube or around a tremie tube inserted into a single inspection tube. Air, water or alternating injections of air and water may be used for flushing.

3. Flushing will continue until no significant solids are observed emanating from the inspection tube and the return flush water is clear, except in the case of erosion of native material, as noted in paragraph 6 below.

4. The Contractor shall monitor the solids content in the wash return water by periodically straining solids out of the effluent.

5. The Contractor shall keep a log of unanticipated communication between holes, water color, type of solids, and estimated solids content.

6. The flushing procedure shall be monitored to reduce the chance of disturbance of the formation around the pile while attempting to remove loose sediment and contaminated concrete. Flushing shall be discontinued if evidence of significant erosion of native material is observed.

C. Water Flow Test

1. A packer shall be seated in the tube below the top of the concrete, or the inspection tube shall be sealed by other means, as deemed appropriate by the Contractor. The Contractor shall be solely responsible for health and safety.

2. Valves on all ports shall be open.

3. Water shall be injected through the grout port.

4. The Contractor shall record pressure, injection rate, signs of communication to other ports, signs of communication to the ground surface, amount of water used, color of return water, and time.

5. After all communicating ports are closed, the water flow testing shall be continued to determine whether there is significant permittivity (flow into

the formation). A water injection rate into the inspection tube of less than 1 gpm at a pressure of 10 to 20 psi (in addition to the existing hydrostatic pressure in the inspection tube) is typically considered insufficient permittivity for permeation grouting. In the case of insufficient permittivity, replacement grouting is to be utilized, unless other factors provide compelling reasons not to utilize replacement grouting.

6. If permeation grouting is to be performed, the water injection rate will be used to help determine an appropriate water:cement ratio for the starting grout mix. The starting grout mix will be determined based on the attached Chart 1. For example, a take of 20 gpm at 10 to 20 psi indicates that a thin starting mix (such as mix #1 presented in the attached Grout Mix Table) is preferred. Take of 10 gpm at 10 to 20 psi indicates that a starting mix such as No. 2 or 3 is preferred. Take lower than 10 gpm indicates that lower water:cement ratios are appropriate for the starting mix, as suggested by Chart 1 and determined in the field by a qualified grouting contractor.

7. If the Contractor suspects insignificant water flow and plans to mitigate by replacement grouting, the falling head test, as described below, may be used as an alternative to the water flow test procedure described in this section. The purpose of the falling head test is to verify that flow is insignificant prior to performing replacement grouting. If the results of the falling head test indicate that flow into the surrounding formation exists, the water flow test described in this section will be performed.

D. Falling Head Test

1. If groundwater is within 25 feet (7.6 m) of the top of the inspection tube, the tube shall be extended a minimum of 25 feet above the groundwater table.

2. The inspection tubes shall be filled to the top with water.

3. If communication exists between tubes, the falling head test shall be performed concurrently in communicating tubes.

4. Flow into the formation will be evidenced by a drop in water level inside the inspection tube. If flow into the formation is demonstrated, a water flow test is to be performed. Replacement grouting is to be performed if flow into the formation is not evident.

E. Down-Hole Camera Observation

1. Down-hole camera observation shall be performed, if required, after high-pressure washing and flushing. The purpose of down-hole camera observation is to verify that the PVC inspection tubes were completely removed from the anomalous zone, to verify that deleterious materials have been adequately removed, and to provide additional information regarding the character and extent of the anomaly.

2. Dry conditions are typically preferable for camera observation. If the flow of groundwater into the inspection tubes is not rapid, i.e., 2 to 3 gpm at 10 to 20 psi, the inspection tubes shall be cleared by air injection after water flow testing and prior to down-hole camera observation or replacement grouting. Camera observation under water may be performed if visibility is acceptable. If camera observation is to be performed under water, flushing will be performed to remove suspended materials from the water within the inspection tubes and scoured anomaly area if visibility is poor.

F. Permeation Grouting

1. The permeation grouting procedures presented below are intended to serve as the standard procedures for grouting. On occasion, it may be necessary to modify the procedures contained herein in response to field conditions to achieve the desired result. The grouting foreman shall have sufficient permeation grouting experience to provide that determination. Any alteration of the standard plan should be clearly identified in the submitted post-mitigation report.

   a. The grouting contractor must evaluate water pressure and rate of take based on water flow test results, as discussed above. If the water flow test indicates that permeation grouting should not be utilized, do not proceed.

   b. Permeation grouting requires that sufficient confining pressure be present to conduct grouting operations without grout returning to the surface. Permeation grouting should not be selected for pile mitigation less than 10 feet from the ground (or working) surface.

   c. The intent of grouting for CIDH piles is to address the structural, geotechnical, and corrosion concerns identified for that foundation element. To that end, grouting purposes to promote the maximum

rate of solids injection, as opposed to the maximum rate of grout injection.

d. The Contractor shall be solely responsible for health and safety.

2. Nittetsu Superfine cement shall be used for permeation grouting. Grout mix ratios and mix designations are presented in Table 1.

   a. The ratios shown in the attached Table 1 are based on Nittetsu Superfine cement packaged in 22 kg bags and having a specific gravity of 2.75. A batch of permeation grout is typically 33 gallons.

   b. Thin grout mixes (such as mixes #1 through #6) are not appropriate for structural mitigation if injected into a void, as they are unstable and will generally not achieve the required design strength.

   c. Due to the small grain size of Nittetsu Superfine cement, the mix becomes thixotropic at a water:cement (W:C) ratio of 0.8:1. The superplasticizer also acts as a retarder. Use of superplasticizer will be determined by the grouting Contractor, as required for favorable flow characteristics and to reduce the chance of grouting equipment damage. The Contractor is solely responsible for performing the grouting procedure in such a manner that equipment does not become plugged or otherwise damaged. Use of superplasticizer shall be in accordance with the microfine cement manufacturer's recommendations.

   d. The actual volume of the voids is not known, and grout solids are likely to enter the surrounding formation. The Contractor shall secure an adequate supply of cement and water for the repairs. The compressive strength of materials permeated with microfine cement solids depends not only on the strength of the grout, but also on the strength of the solid matrix into which the grout is injected. Strength generation is generally slow due to the superplasticizer. Actual strengths will depend upon grout solids permeation and matrix characteristics.

3. The starting grout mix will be determined by the grouting contractor based on the results of water flow testing. The starting grout mix will be in accordance with Chart 1.

4. Grout shall initially be placed by tremie until it returns from the top of the injection port at a consistency similar to the injected grout. If starting

with mix #1 or #2 and significant communication and bleed off is anticipated, initial tremie placement is not necessary.

5. Inflate packers to seal tube. Where multiple tubes are being grouted in the same process, all tubes must be grouted simultaneously by means of a common manifold. Alternate means that accomplish the same intent may be utilized where approved by the Engineer.

6. Batches of grout shall be injected under pressure, beginning with the starting grout mix.

7. At the completion of each batch of grout, the Grouting Contractor shall evaluate the grout take and pressure to determine the thickness of the next batch of grout to be injected. The grout mix will be increased as pressure increases in general accordance with Chart 2. If the starting mix is thicker than the mix indicated by Chart 2, continue to use the starting mix.

   a. The grout mix number is increased as the grouting pressure increases, to reduce the chance of premature refusal during a void filling application and to progressively thicken mix to structural mixes as pores within the grouted material become filled.

8. Inject next batch of grout and repeat Step 7 until refusal is reached. For refusal, see Step 12.

9. If the formation does not appear to be plugging (If the pressure does not increase or flow rate decrease after injection under pressure of three full batches), the grouting contractor may elect to thicken the grout by one mix number.

   a. If mix #7 or #8 does not plug the formation quickly, an ordinary Portland cement grout may be used. The replacement-type grout mix shall consist of Type II Portland cement mixed at the ratio of one 94-pound sack of Type II cement per five gallons of water.

   b. If plugging does not seem to be occurring with Mix #7, Mix #8 or Portland cement grout, the contractor may shut off the pump for intervals of 2 to 10 minutes to assist grouting process.

10. If grout returns to the surface at any time, note the location and estimate the volume of grout seepage. Also estimate the thickness of the return

grout. If the amount of grout return approximates the injection rate, shut off the pump for intervals of 2 to 5 minutes. Use shorter intervals initially or if using thick mixes. In the case of immediate, direct communication, attempt to plug the leak with a half batch of mix #7 followed by a half batch of mix #8.

a. If grout returns to the surface and interruptions in grouting do not control the leak, the contractor may thicken the grout to the thickest mix possible and discontinue grouting when the thick grout reaches the surface. Identify this condition in the post-mitigation report.

11. The contractor shall consider known difficulties associated with thick mixes and plan accordingly.

    a. When using thicker mixes such as #7 or #8, check the pressure frequently and be prepared to dilute the mix if signs of plugging in the hoses or fittings are noted (plugging is common with this mix). If the mix is diluted to address plugging of the equipment, do not inject the thinned mix into the pile.

    b. When pumping mix #8, look for signs of hydro-fracturing and test for refusal frequently. (Mix #8 has a very high viscosity and will permeate only a few inches in most geomaterials.)

    c. Mix #8 is often mixed in half-batches, especially for small grouting operations.

12. Refusal is defined as zero take at 150 psi. Grouting pressures shall be held for five minutes prior to release.

    a. Refusal must be achieved with a sufficient quantity of structural grout mix (#7 or #8) for the grouting operation to be considered complete. If refusal is achieved during permeation grouting prior to injection of sufficient quantity of a structural grout mix, mix #8 will be tremied to the bottom of the anomaly location to completely displace thinner mixes.

        i. For the purposes of Step 12a, "sufficient quantity" is considered to be greater than or equal to the estimated volume of the cavity developed by high-pressure washing, plus the volume of the tube/grouting port, plus the volume contained in the hoses above the anomaly to the grouting batching plant.

ii. Filling of the anomalous zone by tremie will be confirmed by consistent return of mix #8 at the top of the tube.

iii. Upon filling, the grout is to be pressurized to approximately 150 psi and held at that pressure for a minimum of five minutes.

iv. A sudden pressure drop at high pressures may be a sign that hydro-fracture of the formation has occurred during refusal. Indications of hydro-fracture are to be identified in the post-mitigation report.

13. All Equipment utilized by the Contractor shall be used according to manufacturer's recommendations in a safe manner that will result in the desired finished product.

a. The grout mixing and pumping unit shall be a colloidal mixer with a progressive cavity injection pump (Chem Grout colloidal mixer or approved equivalent).

b. Pressure gauges shall be bourdon tubes with 4% accuracy. Gauge protectors shall be used and the gauges shall be replaced on a three- to four-shift cycle. The pressure range of the gauge shall be selected to allow for the anticipated grout pressure to fall in the middle third of the pressure range.

G. Replacement Grouting

1. The inspection tube shall be completely cleared of water. Extra care is required to assure all water is removed, as residual water will block the grout from completely filling the cavity. Begin tremie placement in all tubes associated with the anomaly as soon as the water is cleared.

2. The anomaly and inspection tube shall be filled with grout by tremie from the bottom of the voided inspection tube. The tremie shall be maintained below the level of the grout during placement. The tremie shall be extracted when the inspection tube is completely filled with grout.

3. After the inspection tube is completely filled with grout, the grout shall be pressurized through a port installed in the inspection tube to a minimum of 150 psi and held at that pressure for a minimum of five minutes. The Contractor shall be solely responsible for health and safety.

4. Grout shall conform to Section 50-1.09 of the Standard Specifications and shall consist of Type II cement mixed at the ratio of one sack of cement per five gallons of water. Using a 94-pound sack of cement, the water:cement ratio would be approximately 0.44. The Contractor shall verify that the grout strength corresponds to the required design strength.

5. The Contractor shall have an adequate supply of cement and water for the repairs.

H. Reporting

1. Upon completion of the mitigation procedure, a mitigation report shall be submitted to Caltrans stating what repair work was performed and whether the repair work conformed with the mitigation plan. Any deviations from the mitigation plan shall be stated in the report, including an explanation of the compelling reason that prompted the modification.

2. The mitigation report shall contain a summary of the repair procedures, which typically includes a summary of observations made during the repair, comparison of the anticipated anomaly volumes with the actual grout quantities used, and the results of testing if performed.

Table 1 – Grout Mix Table						
Mix	Cement (bags)*	Water (gallon)	Weight (lbs)	Volume (gallons)	Density (lbs/gal)	W/C
1	1.0	33.0	319.2	34.9	9.1	6.3
2	2.0	33.0	363.2	36.8	9.9	3.1
3	3.0	33.0	407.2	38.8	10.5	2.1
4	4.0	33.0	451.2	40.7	11.1	1.6
5	5.0	33.0	495.2	42.6	11.6	1.3
6	6.0	33.0	539.2	44.2	12.2	1.0
7	7.0	33.0	583.2	46.0	12.7	0.9
8	8.0	33.0	627.2	48.0	13.1	0.8

Note: * Based on 22 kg per bag.

Chart 1 - Starting Mix for Permeation Grouting

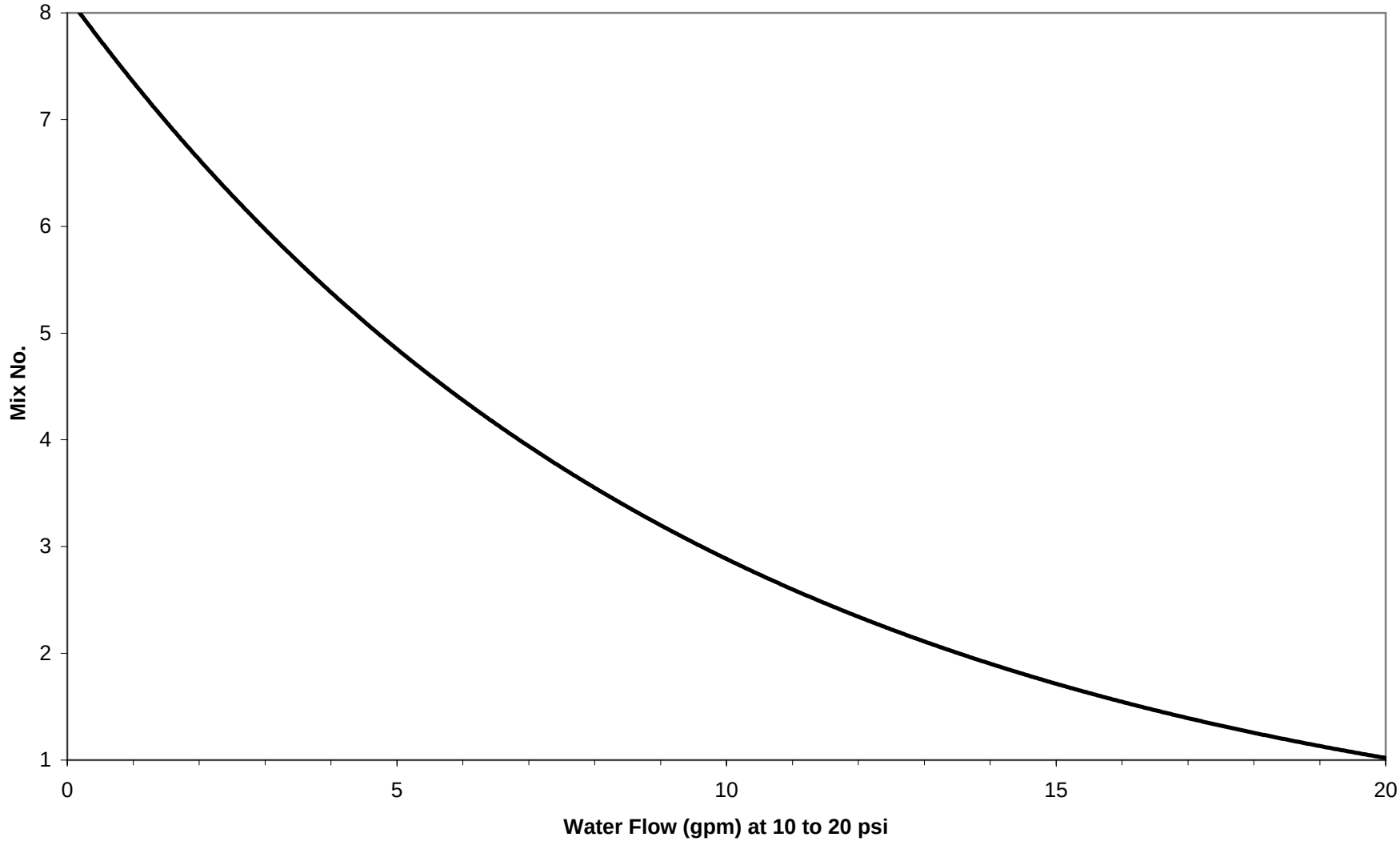
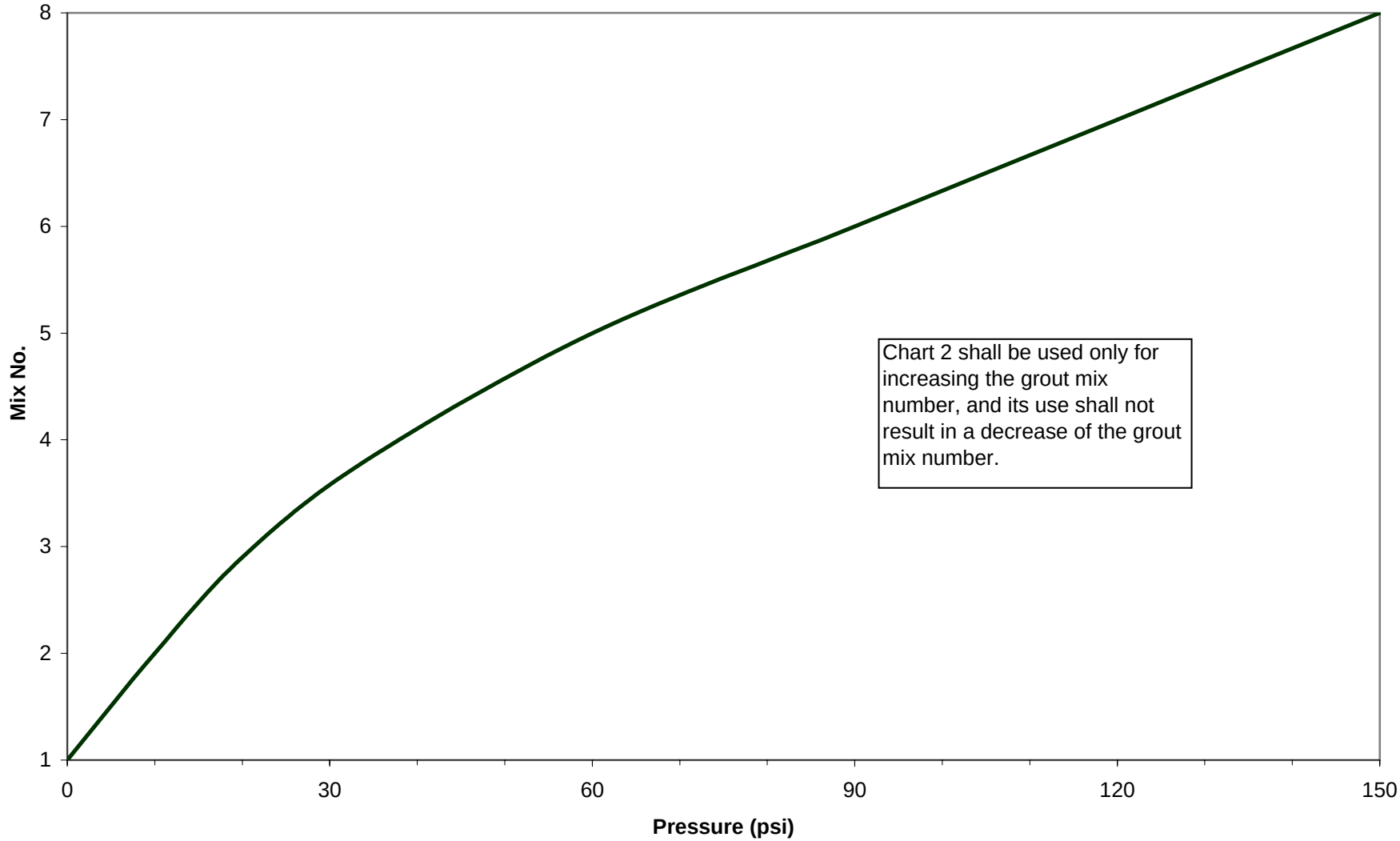
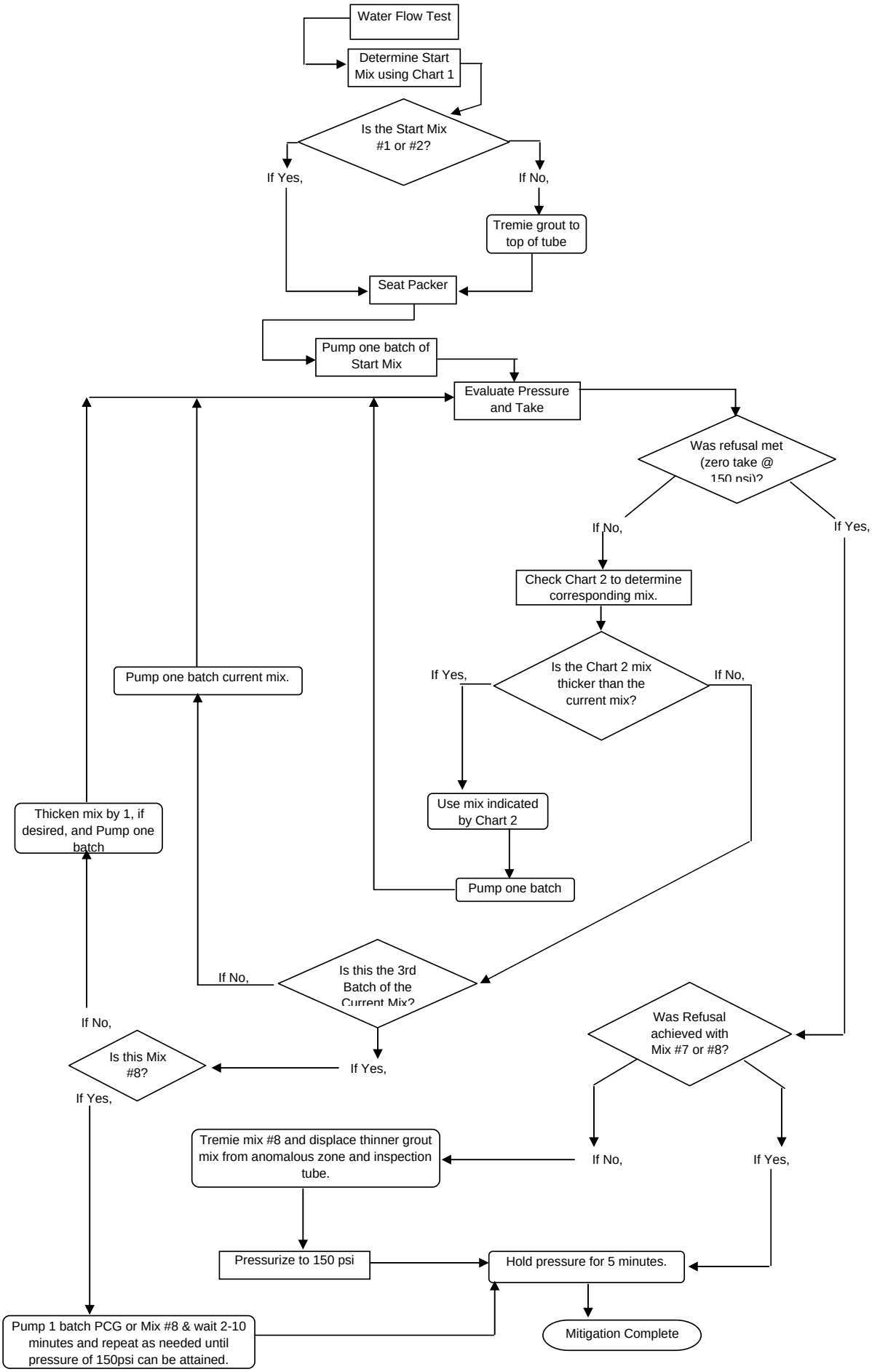


Chart 2 - Relationship Between Mix Number and Pressure for Permeation Grouting



Permeation Grouting Procedure for CIDH Pile Repair



Example - Summary of Anomalies Detected During Acceptance Testing
Standard Mitigation Plan

Bent No.	Approximate Depth Interval of Anomaly[1] (measured in feet from top of pile)	Approximate Depth of Bottom of CMP Liner (feet)	Inspection Tubes	Apparent Length of Anomaly (ft)	Estimated Maximum Percent of Cross Sectional Area[1,2]	Estimated Maximum Volume of Anomaly[2,3] (ft^3)	Proposed Repair Interval (measured in feet from top of pile)	Proposed Repair Method
3	21-23	31	1-5, 8-10, 12, 13	2	71	188	18-25	permeation / replacement grout
4	18.5-20.5	35	1-7, 9-14	2	93	247	15.5-22.5	permeation / replacement grout
5	28-29.5	40	1, 4-7, 10-14	1.5	71	141	25-31.5	permeation / replacement grout
5	43-44	40	1,4	1	14	19	n/a	none

Notes:
1. Based on acceptance test report.
2. Maximum percent of cross sectional area was estimated based on GGL results by assuming that each of the 14 inspection tubes accounted for 1/14 of the total cross sectional area. Based on CSL results, the anomalies are likely to be located primarily on the exterior of the rebar cage. Thus, actual percent of cross sectional area affected and anomaly volume may be significantly less than the estimated maximum area and volume.
3. Based on 13-foot nominal pile diameter.

SAMPLE CIDH PILE ANOMALY MITIGATION FIELD REPORT

HOLDREGE & KULL
CONSULTING ENGINEERS • GEOLOGISTS

	Project Name:	Project No.:	Report No.:
	Pier # Pile #	Date:	Weather:
	Client:	Contract No:	PO/WO#:
	Project Location:	Client's Rep:	Appl.#:
Gave A Copy of This Report To:	Grouting Contractor:	Foreman:	Results To:

SCOPE OF WORK		STATUS OF PROJECT		SAMPLE LOCATION
High Pressure Cutting		On-Going		ID No.
Pressure Washing		Complete		ID No.
Pressure Testing		Completed Phase:		Sample Notes:
Permeation Grouting		Letter to Follow		
Tremmie Grouting		On Hold Due To:		

SUMMARY OF OBSERVATIONS

Time	Tube No.	Mix No.	Batch No.	Pressure (psi)	Cement/ Batch (lbs)	Take (gallons)	Notes

Field Rep.:	Signed	Page of	grout 4-05

SUPER FINE GROUT MIX PROPORTION

◆Super Fine Grout

(1000 L)

Water:SF ratio	Water (L)	DA (kg)	SF (kg)	Compressive Strength (MPa)	
				7 days	28 days
0.6:1	634	10.7	1,071	19.5	40.2
0.8:1	699	8.8	882	15.2	31.7
1:1	750	7.5	744	9.8	23.6

SF ： Super Fine (Nittetsu Cement Co.,Ltd)

DA (Dispersion Admixture) ： Mighty 150R (Kao Corporation)