

YELLOWSTONE PARK COMPANY

D-513

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CANYON

VILLAGE

FACILITIES

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SURVEY

of

CANYON VILLAGE FACILITIES

for

YELLOWSTONE PARK COMPANY

An analysis of existing installations and conditions, primarily concerning cabins and cabin areas, and pertaining to:

1. Heating System Operation and Control.
2. Movement in Cabin Structures, due to frost upheaval.
3. Acoustical Control within Cabin Units.

Precedent Office

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SECTION 1

PURPOSE AND SCOPE

A. PURPOSE.

Since completion of the Canyon Village project in 1957, several design and construction deficiencies have proved so serious as to exceed the capabilities of a maintenance program in attempting to cope with deterioration and control. Questions of continued public acceptance, evidenced by constant and justifiable complaints, together with the specter of increasing maintenance costs raises the larger question regarding the possibility of future successful operation.

The need for comprehensive action is indicated if this new project is to be represented to the travelling public as deluxe accommodations; or even to effect such remedial work as will allow reasonable maintenance to cope with residual problems - for which additional capital investment cannot be allowed.

To this end a determined management has asked for a complete, rigorous and conclusive study as a first step in initiating such a course of action.

B. SCOPE.

The firm of Orr Pickering and Associates was directed in July to study the Canyon Village guest unit installations and to report information, conclusions and recommendations regarding deficiencies in the following categories:

1. The Central Heating Plant, Distribution System, Building Heating Systems and Control.
2. Damaging Movement in Cabin Structures; involving Foundations, Site Improvement and Control of Frost Upheaval.
3. Control of Acoustics between Guest Units.

In brief, for each of the above categories, the survey and this report intend to provide answers to such rudimentary questions as -

What is the present situation?

What is wrong with the present situation - when, why or how did it become so?

What can and/or should be done about it?

How much will it cost?

SECTION II

COMPENDIUM

A. PROCEDURE

1. Review of available file material to ascertain original scope and design criteria; also to evaluate factors involved in project development from inception, through design, to construction and acceptance.
2. Field Work.
Observation, physical measurements, interviews with personnel, and experimental installations.
3. Office review and compilation of data, computations, graphical analysis, and evaluation.

SECTION II

COMPENDIUM

B. FINDINGS

1. General.

- a. Many of the existent problems are due to early errors in judgement or practice of false economy, in establishment of proper design criteria, inadequate review of preliminary design, disregard of known fact concerning site information, unaccountable and critical deficiency in supervision and control of construction quality, and lack of delegation of authority to qualified YP Co. personnel during job progress.

Acknowledgement: It is easier "to quarterback on Monday than during Saturday's game". The above observations hold true none-the-less.

- b. Most of the problems have been recognized (even predicted) and lived with by YP Co. personnel since job completion. Many correct solutions have been studied out and proffered, but not effected for lack of administration and/or funds.

2. Heating System.

Requirements for satisfactory operation are:

- a. Replacement of approximately 2/5 of existing convectors with units of adequate capacity.
- b. Installation of individual automatic controls for each room unit.
- c. Installation of secondary booster pumps on outlying cabin units and differential pressure regulating valve assemblies on close-in cabin units.
- d. Increased capacity of all system circulating pumps in the Boiler Room.
- e. Modifications and additions to Boiler Room equipment and piping for proper handling of de-aerating feed water, condensate return and flash steam.

3. Movement in Cabin Structures.

- a. Trouble experienced in the spring of 1957 during construction period was investigated by original soil and foundation engineering consultants and resulted in recommendations for remedial action. Those recommendations have never been satisfactorily implemented and are as valid today as they were six years ago.

SECTION II

COMPENDIUM

B. FINDINGS

3. Movement in Cabin Structures (Continued)

- b. Investigations of actual foundations commenced as early as July 1957 by YP Co. personnel and subsequent excavations exposed gross violations of contract requirements (documented by photographs in YP Co. files).
- c. Site drainage - both surface and subsurface - has never been properly accomplished. Of all the major contributing factors to frost upheaval, it is the one needed improvement that directly affects the feasibility of any other type of correctional work. It is also the first most obvious step to be taken to bring under control the cabin structure movement, is the most easily accomplished and may be the only economically feasible course of action.

It is perturbing to realize that the responsibility for site drainage was and is that of the National Park Service as a matter of site selection, site improvement, storm drainage and landscaping.

- d. Movement of structures can be tolerable within limits without evidences of undue distress appearing in interior or exterior elements. Possibly, if proper site drainage is effected, movement can be reduced to such limits.
- e. If tolerable limits cannot be experienced by correction of site drainage alone, the aspects of further work raise serious doubts as to the comparison of the cost of such work with the value of the structure itself.

4. Acoustical Control

- a. Problems of acoustical control are "built-in" as a result of design and construction; probably dictated to some extent by economics. Only a cursory treatment was given to an element of design which if warranted requires consideration even in the basic structural frame.
- b. Determinations of present acoustical values were made by use of a standardized and uniform procedure including the use of sound generating and measuring equipment.
- c. It was recognized that correctional work must utilize standard materials and inexpensive techniques.

SECTION II

COMPENDIUM

C. CONCLUSIONS AND RECOMMENDATIONS

1. Heating System

- a. Present system cannot be modified for satisfactory operation without extensive work and considerable cost.
- b. Cost of modifications appears to exceed that of an entirely new and complete L.P. gas heating system; including unit-type space heaters, water heaters, L.P. gas storage tank, piping and total installation.
- c. Obvious recommendation - make the change to the new system.

2. Movement in Cabin Structures

- a. Corrective work on the cabins themselves is not practical without first correcting site drainage to eliminate excess ground water. Work on cabins would require modifications to or replacement of footings and feasibility is questioned on basis of cost.
- b. The question of inadequate site drainage looms over all. Resolution of this problem affects either directly or indirectly the handling of other current problems in the entire cabin unit complex.
- c. Since site drainage is the province of the NPS, it is recommended that the YP Co. encourage joint studies to head up a program for installation of a complete site drainage system.

3. Acoustical Control

- a. It has been demonstrated that appreciable improvement can be realized by modifications to existing walls and addition of double communicating doors. Installation of ceilings is helpful and offers indirect advantages in regard to heat loss and appearance, but does not accomplish acoustical control commensurate with cost.
- b. Since acoustical installations are contingent on correction of cabin movement it is recommended that this be a matter of budgeting of funds only for future programming.

SECTION III

GENERAL CONSIDERATIONS

A. ORIENTATION OF SURVEY WORK

A review of all available data and drawings in the YP Co. files has been made with the object (and result) of gaining knowledge and an appreciation of the development of the Canyon Village project and its current problems.

Phases of particular interest are:

- (1) Original concepts and design. Anticipated problems and decisions.
- (2) Construction procedures, field problems and disposition. Changes.
- (3) Quality of control and supervision.
- (4) Early experiences as a guide to final acceptance.
- (5) Subsequent experience, modifications, maintenance and repair

B. INTERIM ACTION (Since project completion)

1. YP Co. personnel of various capacities and at various times have coped with and investigated rising problems, accomplished expedient and piecemeal remedial work and experimented during the past six years. The satisfaction of decisive conclusions and action was never permitted by such factors as lack of money, time, extension of authority and/or interested administration.
2. Maintenance crews have had to live with problems on a day-to-day basis and corrective work has been of a stop-gap nature resulting in continued expenditures of minor amounts. Cumulative and rising costs have been considerable and for work without proper or permanent results.

C. THE PRESENT ATTITUDE OF MANAGEMENT

Apprehension for growing public sentiment and the recognition of increasingly untenable deficiencies has spurred the need for a positive and conclusive program of analysis and action.

This survey will constitute the first coordinated and comprehensive analysis initiated by management and sanctioned by administration.

- D. It is here acknowledged that this report illumines portions of information already on record in the YP Co. files. Some of our work has been to sort out, validate and put in proper perspective, data pertinent to the survey.

SECTION V

MOVEMENT IN CABIN STRUCTURES

A. PROJECT DEVELOPMENT AND CONSTRUCTION

Notable items and Comments.

1. Early correspondence evidences concern for design criteria and approach to problems of frost heaval, footing design and drainage.
2. A foundations investigation and report was made by consulting engineers for the project structural engineer in August 1956. This report contained information dealing with the complex and erratic conditions unique to the site and made specific recommendations regarding appropriate design. Acknowledgement was made that, for several reasons, "...as detailed a subsoil investigation has not been done as would normally be done." It also recommended, because of limited investigations, "...it would be advisable to have our firm make inspections and reviews during the foundation construction operations,...."
3. Original footing designs were changed, by Work Order #104 in May 1956, to larger and deeper piers.
4. Job progress was slow and under adverse site conditions. Workmanship and inspection was notoriously poor, according to verbal accounts; this was substantiated later by inspection of excavations investigating foundation failures.
5. Excessive movement in cabin foundations was first noted in the spring of 1957 on structures in various stages of completion. Detailed investigation and measuring followed including an analysis and report by the original foundation consulting engineers. Their report listed several recommendations for corrective work most of which was never accomplished. These recommendations are still valid.
6. Certain corrective work was subsequently performed by the project contractor and the cost was billed to the YP Co.

SECTION V

MOVEMENT IN CABIN STRUCTURES

B. PREVIOUS REPORTS

In our review of voluminous material in the YP Co. files for the Canyon Village Project, we find several noteworthy reports containing pertinent and valuable information as a matter of reference and record.

We believe that they are valuable because they were written by qualified people concerning the problems here considered and perhaps the more so since they were written at the time these problems were first recognized.

They are as follows:

1. "Foundation Investigation for Proposed Commercial Buildings and Cabins at Canyon" prepared by consulting engineers (soil and foundation engineering) in August 1956.
2. Report on "Differential Movement in 13 Cabins in Area "C", Canyon Village" by the same engineers as above in August 1957.
3. Memorandum on "Frost Damage - Motel Cabins, "C" Area, Canyon Village" to the Vice President of the YP Co. from the Manager, Construction Dept. dated July 23, 1957.

SECTION V

MOVEMENT IN CABIN STRUCTURES

C. ASPECTS OF FROST UPHEAVAL

It seems appropriate at this point, to briefly review some of the recognized considerations involved in frost heaving of small footings. Recognition of these aspects was given in the original and supplemental report of the foundations consulting engineer and the footings, for the most part, were designed accordingly.

- (1) Minor heaving occurs when a mixture of mineral soil and water freezes - total volume increases from 2 to 5 percent.
- (2) Major heaving is caused by formation of relatively pure ice lenses at the boundary of frozen and unfrozen soil. They form as the frost penetrates the soil and can cause surface heaving of from 6 to 12 inches.
- (3) Most buildings have footings extended below the depth of frost penetration and the heaving that occurs is not associated with the soil under the footing. Rather the heaving occurs when the soil on the sides of the footing pier grips the pier. Tests indicate that the bond between the concrete and the frozen soil is on a high order.
- (4) It is believed that growth of ice lenses is made possible by water moving upward in the capillary channels of the unfrozen soil toward a liquid film in contact with the ice lens. Such capillary action in free draining granular soil is negligible and these soils are usually not susceptible to frost heaving.
- (5) The rate of frost penetration, the duration of freezing conditions and the availability of water also affect the development of ice lenses. Snow, because of its insulating properties, will usually retard frost penetration if the snow cover is heavy enough. (Note that we do not have the benefit of snow cover under the vital area beneath the cabins.)

There are several ways to minimize frost heaving; only a few have (or would have had) application in our situation. They are:

- (1) Eliminating the grip of the frozen soil on the sides of a footing; this permits the soil to heave without affecting the footing. (Note it was suggested that "Sonotube" forms, waxed cylindrical cardboard forms, be used at Canyon Village but the suggestion was rejected on the basis of cost.)

SECTION V

MOVEMENT IN CABIN STRUCTURES

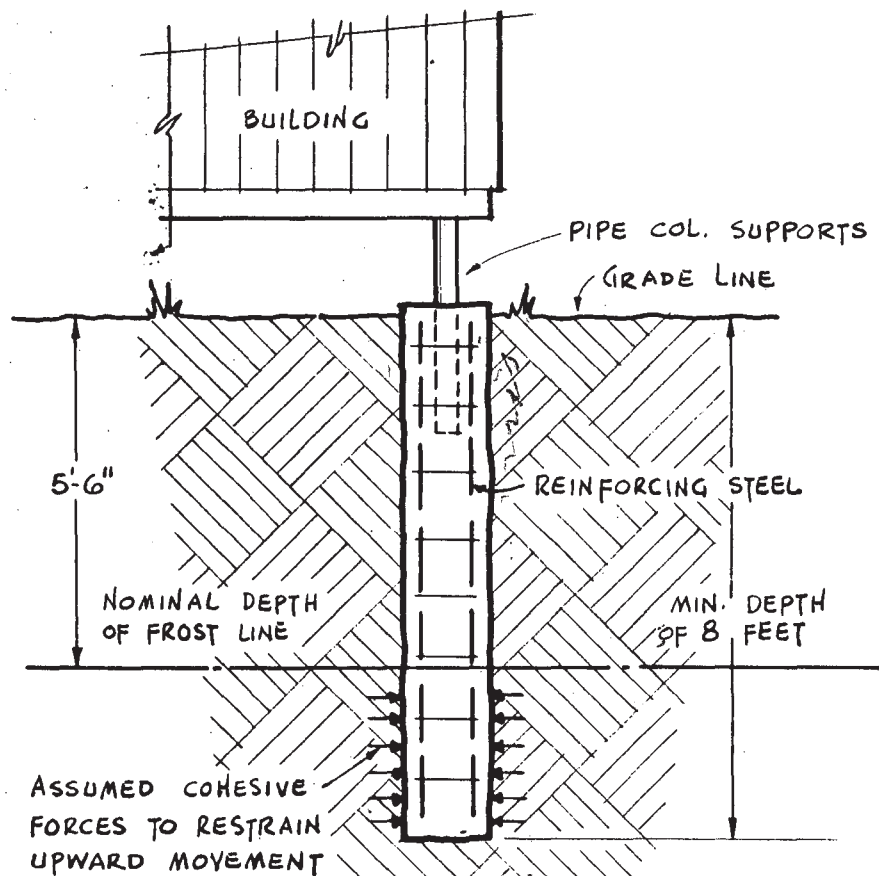
C. ASPECTS OF FROST UPHEAVAL (Continued)

- (2) Replacing the soil adjacent to the footing with free-draining material that is not frost-susceptible.
- (3) Lowering the ground water by drainage.

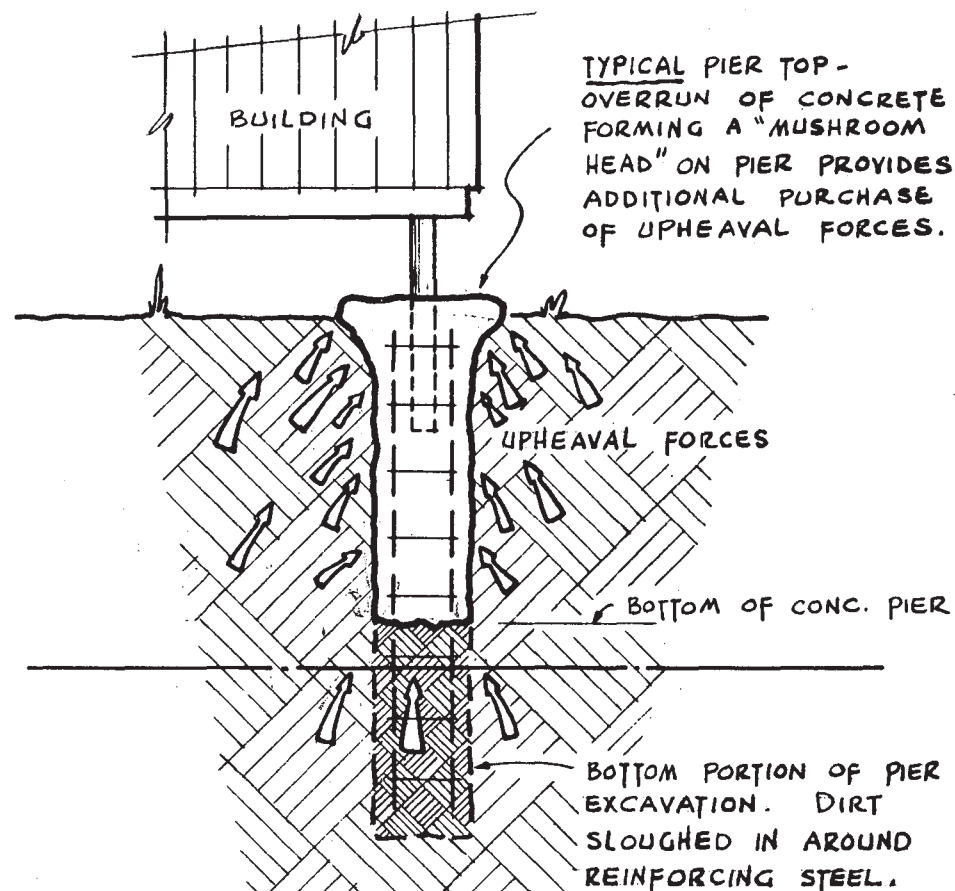
The design of the cabin footings, in lieu of eliminating the frost grip, was based on the premise that if the footings were extended deep enough below frost line (or into the bedrock as the case might be) the bond developed by skin friction on the surface below the frost line (or the bond with bedrock) together with the dead weight of the loaded pier would be sufficient to offset the lifting action of the heaving material above.

Regretably, the footings as built were obviously not deep enough to withstand the forces acting around them. These forces were further intensified by the presence of excess water. Compounding the situation was the fact that many piers were poured with an "over-run" of concrete at the top forming a "mush-room head". This gives uplifting forces a tremendous purchase on the pier in addition to the grip on the sides.

The sketch on the following page illustrates the "designed" and some "as-built" footings. This information is based on excavations made to investigate the footings and is well documented by photographs in the YP Co. files.

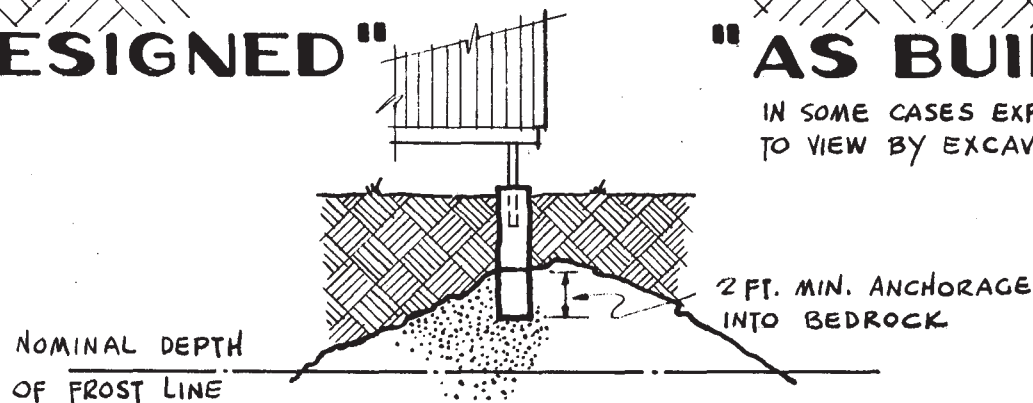


"AS DESIGNED"



"AS BUILT"

IN SOME CASES EXPOSED TO VIEW BY EXCAVATION



ALTERNATE DESIGN FOR CASES WHERE BEDROCK WAS FOUND ABOVE MIN. DEPTH

SECTION V

MOVEMENT IN CABIN STRUCTURES

D. APPRAISAL OF PRESENT SITUATION

1. Procedure.

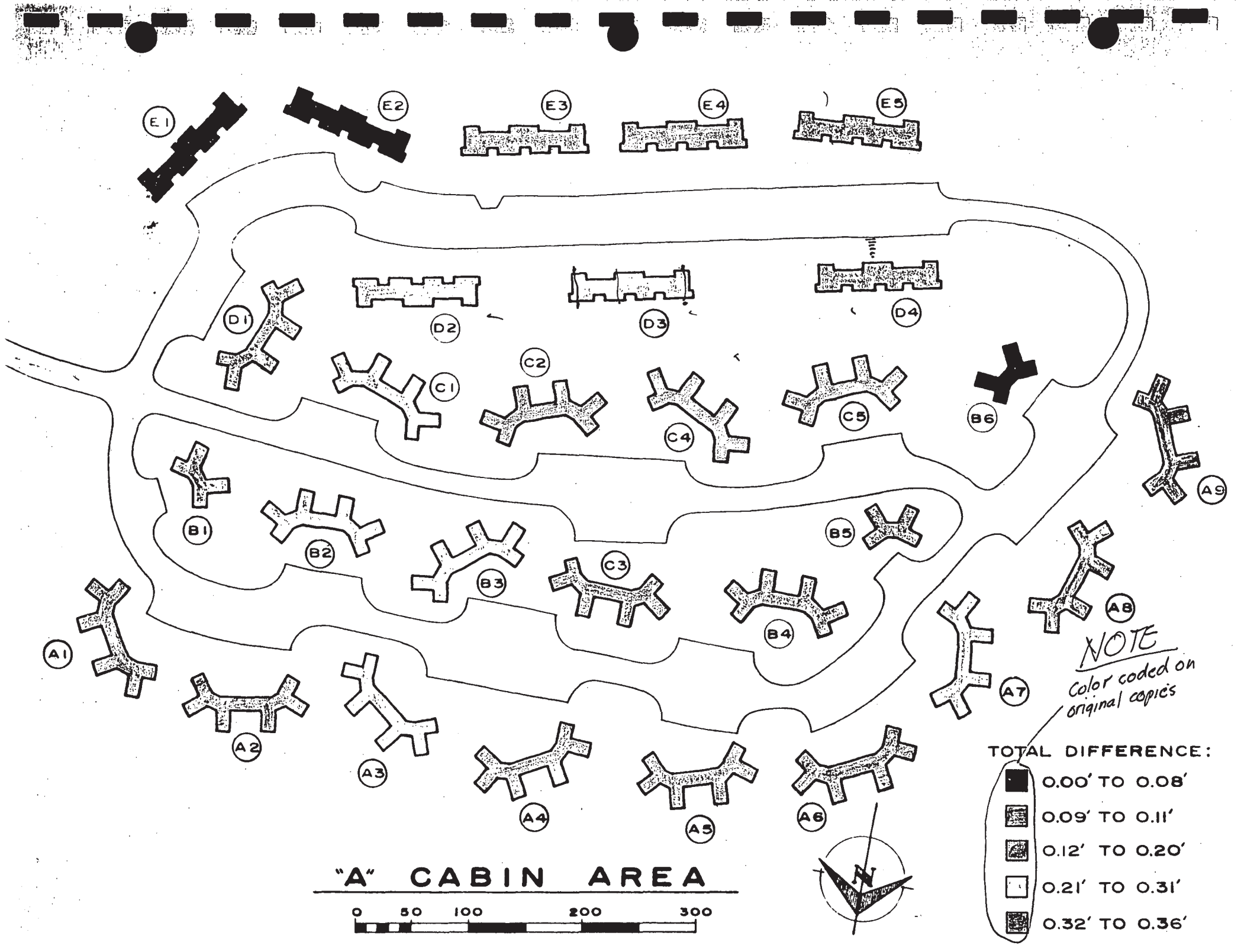
- a. Our first objective was to record the current condition of the cabin structures by measuring each cabin and noting the degree and location of movement and damage.

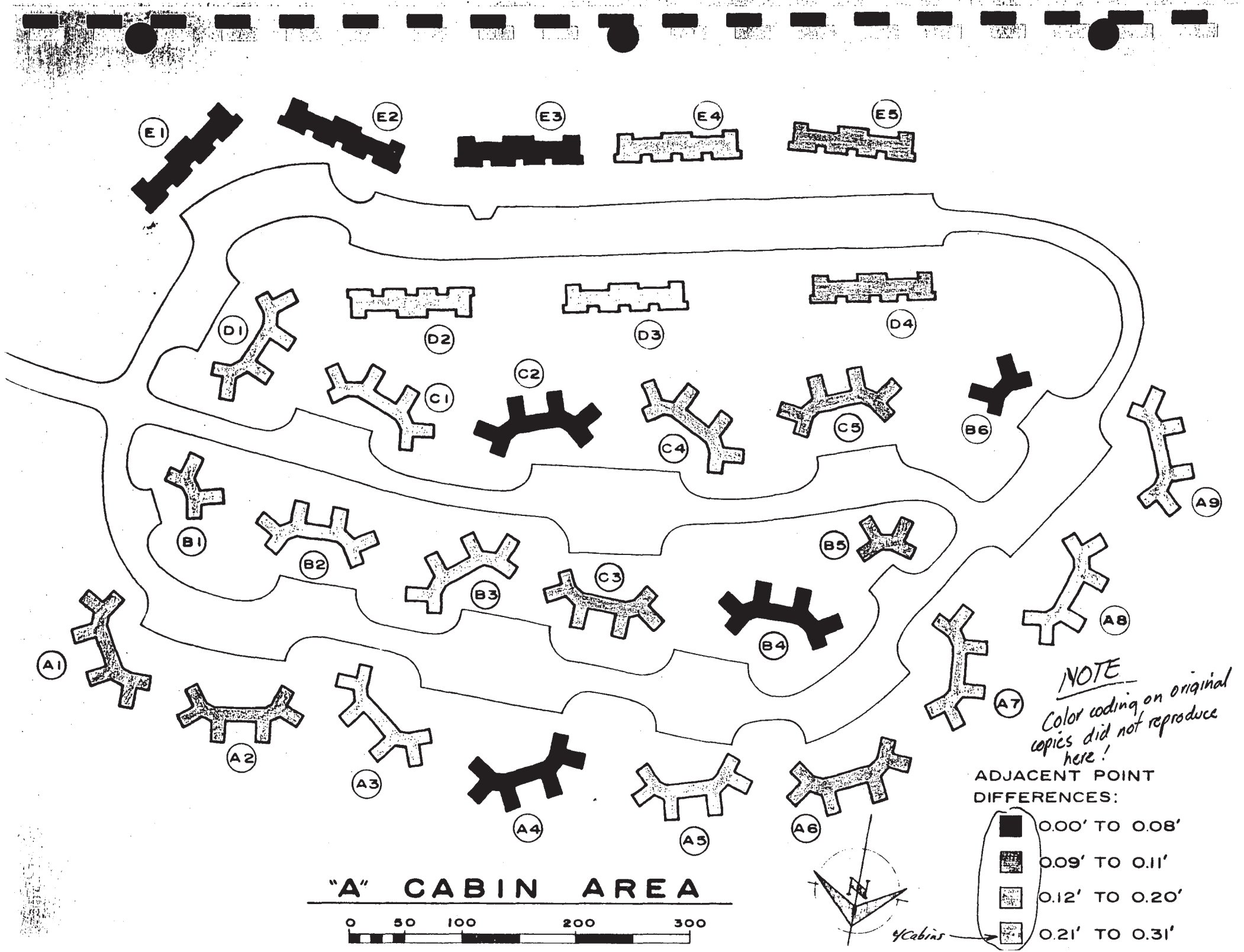
Levels were taken on all cabins by measuring all corners on the roofs. After taking levels both at the sill line and at the roof level, it was found that foundation movement was reflected in the roof system with sufficient accuracy for the purposes intended. (Incidental note - all roofs are in remarkably good condition.)

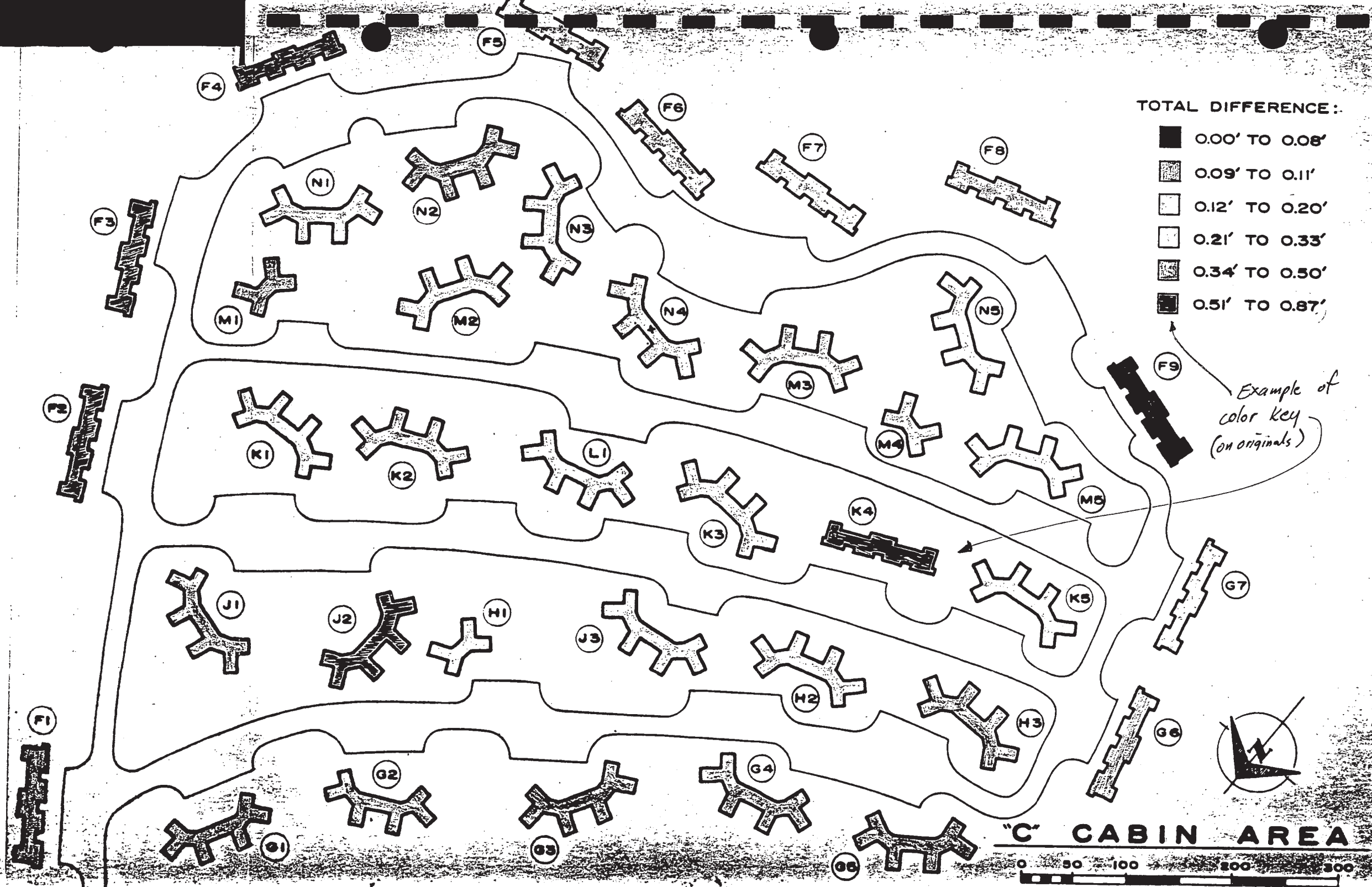
Where extreme variations in levels were found the above-ground portions of footing piers, floor framing, interior framing and interior finish were inspected and condition noted.

Sufficient cabins, in all stages of movement, were entered and conditions noted to determine relationship between degree of movement and evidences of "distress" of framing members, finish, doors and other elements. These observations later serve as a basis for establishing what we will call tolerable limits of movement.

- b. Drainage conditions were then studied visually with regard to surface, or storm drainage, and subsurface water disposition.
 - (1) Surface drainage patterns were plotted on site plans for both areas with particular regard as to their relationship and effect on each individual cabin. Absence of gutters, evidences of surface erosion, variations in vegetation, soft or wet areas and other indications vividly tell the story of what happens to storm and runoff water.
 - (2) "As constructed" site improvement drawings prepared by National Park Service were studied and then checked on the site for verification of information shown concerning drainage installation, both for surface and subsurface water.







TOTAL DIFFERENCE:

- 0.00' TO 0.08'
- 0.09' TO 0.11'
- 0.12' TO 0.20'
- 0.21' TO 0.33'
- 0.34' TO 0.50'
- 0.51' TO 0.87'

Example of
color key
(on originals)

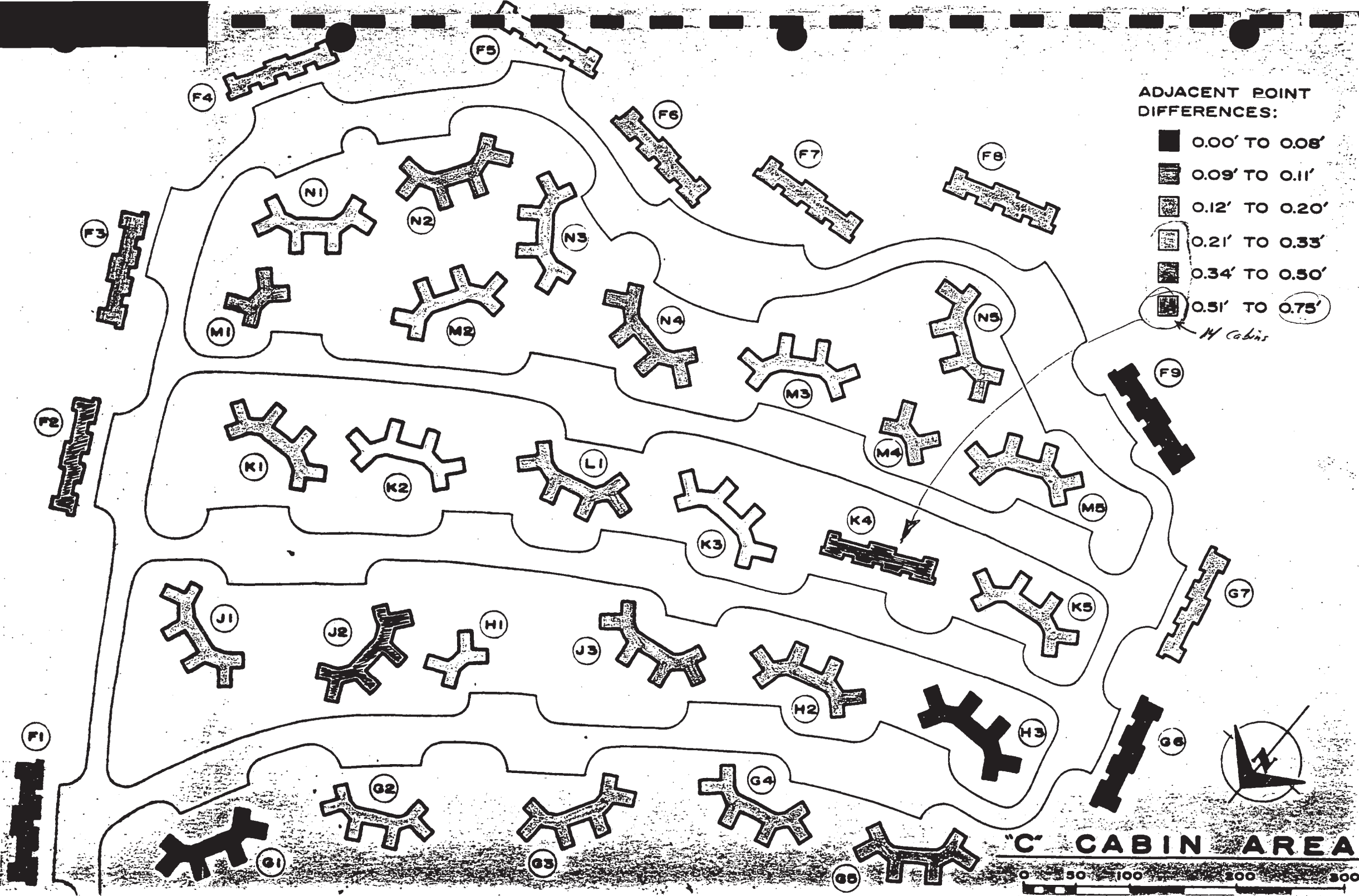
"C" CABIN AREA



ADJACENT POINT
DIFFERENCES:

- 0.00' TO 0.08'
- 0.09' TO 0.11'
- 0.12' TO 0.20'
- 0.21' TO 0.33'
- 0.34' TO 0.50'
- 0.51' TO 0.75'

H Cabins



"C" CABIN AREA

0 50 100 200 300

SECTION V

MOVEMENT IN CABIN STRUCTURES

D. APPRAISAL OF PRESENT SITUATION

2. Findings.

a. Cabin Movement -

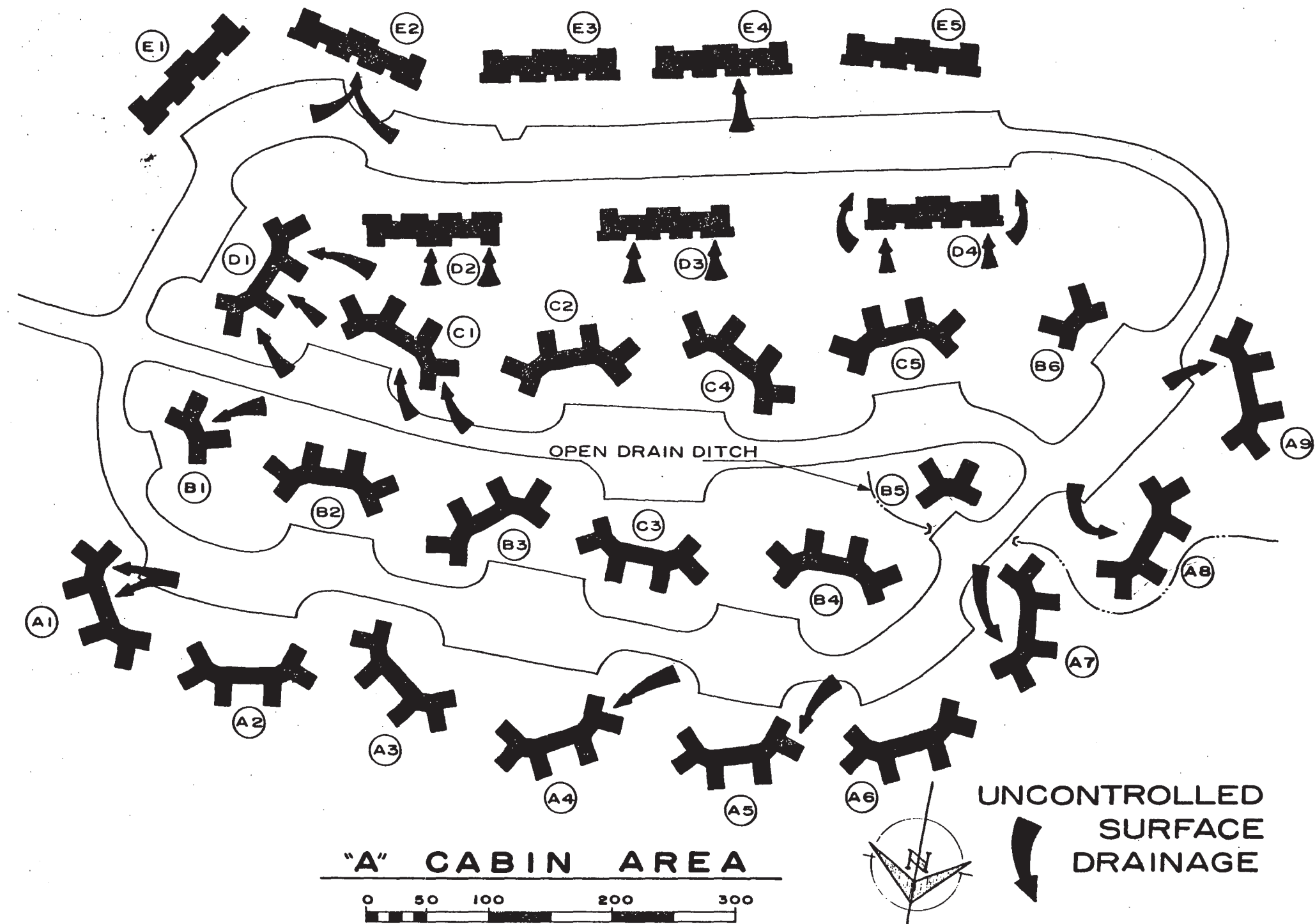
Drawings on the preceding pages show a plotting of the ranges in movement for each cabin in two different manners. For instance, one of the "A" area site drawings shows the maximum difference in total readings of high and low points wherever found, on any cabin expressed as being within a given range which is designated by a color. The other "A" area site plan shows similarly the maximum difference between any two adjacent points.

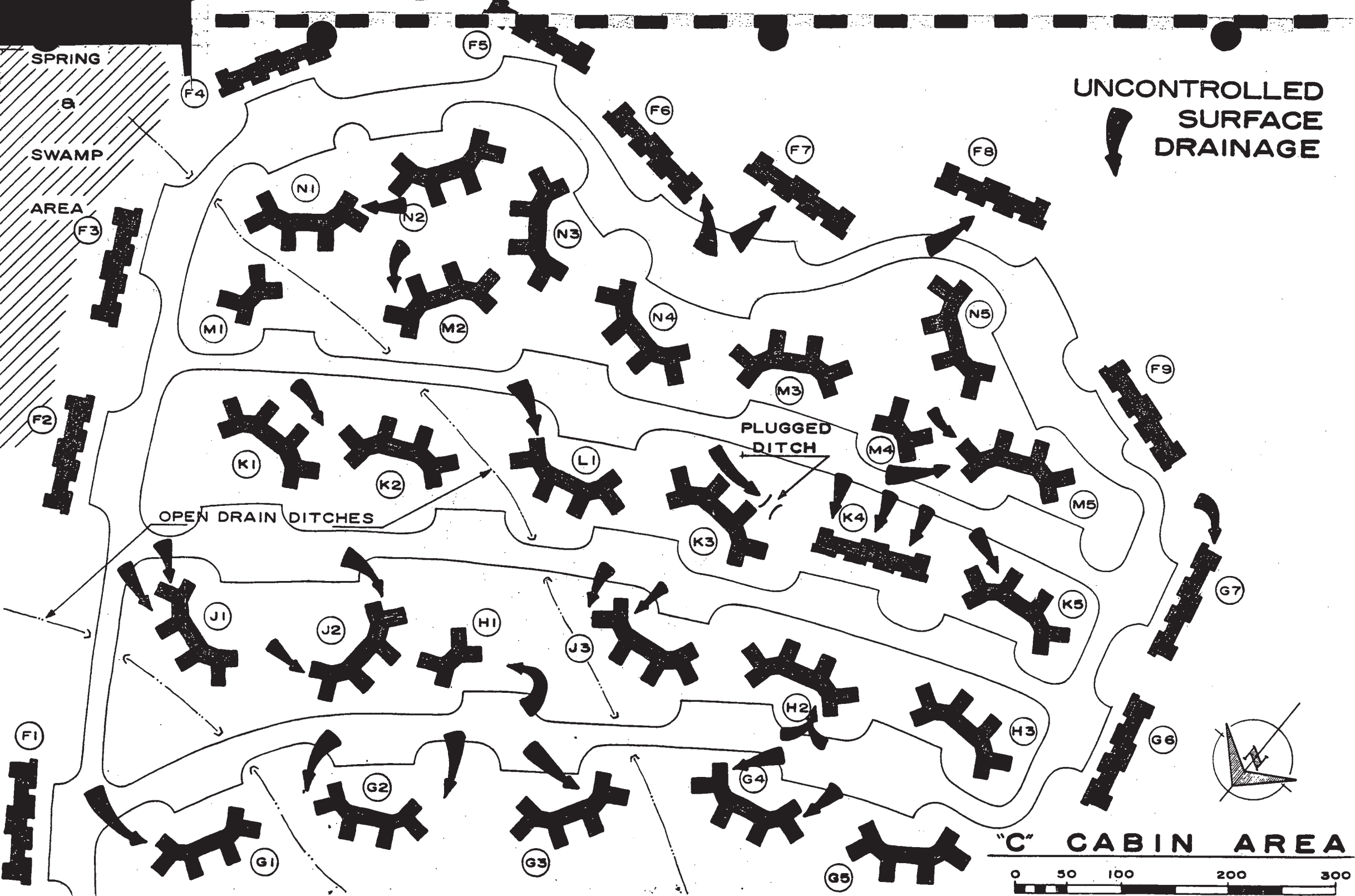
Differences in total readings give an idea of general movement of the cabin as a whole whereas differences between adjacent points show severity of localized movement and is an indication of trouble or "distress" in cabin structure.

It might be reasonably assumed that differences between adjacent points of 0.2 foot (2.4 inches) is within a tolerable limit. With this assumption it can be stated that four out of 29 cabins in the "A" area and fourteen out of 38 cabins in the "C" area show excessive movement as of now.* This amounts to 14% of "A" area cabins and 37% of the "C" area cabins which have been damaged.

Almost invariably, wherever significant movement has occurred, the casual observer can note the presence of a "mushroom" headed pier protruding above grade level.

* That is, in their present "cycle" of movement and in their present state of repair. By next spring the picture may be quite different.





SECTION V

MOVEMENT IN CABIN STRUCTURES

D. APPRAISAL OF PRESENT SITUATION

2. Findings. (Continued)

b. Drainage -

Review of the two drainage charts on the preceding pages will show direct correlation between cabin movement and either uncontrolled surface drainage or subsurface drainage. This explains the reason why most movement and damage has occurred in the "C" area.

Physical measurements on the site and complex analyses are not necessary to demonstrate that excess ground water is present and is one of the prime causes of frost upheaval.

Grading of ground areas underneath the cabins in the typical situation tends to accumulate surface drainage. This coupled with the fact that those areas are vulnerable to frost penetration (due to lack of snow cover, as previously explained) constitutes one more contributing detrimental factor.

Our comparisons made between the NPS "As Constructed" site improvement drawings and the actual site work was disatisfying. Many discrepancies were noted (i. e., missing buildings, variations in paving and parking areas, etc.) which although not in themselves pertinent to drainage, raise doubts as to the drainage items shown. No visual evidence could be found of some of the underground piping indicated. We did find open swales or ditches in some locations shown to contain underground drainage piping.

Whatever subsurface drainage piping there may be is quite apparently undersized, plugged, improperly installed or otherwise ineffective; if it was, in fact, all installed in the first place. Standing water over our shoetops (in a dry August) within 20 feet of cabins at the East end of "C" area is mute testimony regarding the underground perforated metal pipe shown on the drawings at that location.

c. Corrective & Maintenance Work -

Work performed to date by YP Co. personnel:

(1) Cabin movement results in damage of varied forms:

- Separation and fractures of framing members.
- Fractures and splitting of finish surfaces and trim.
- Uneven floors and loose floor tile.
- Racking and binding of doors and windows.

SECTION V

MOVEMENT IN CABIN STRUCTURES

D. APPRAISAL OF PRESENT SITUATION

2. Findings.

c. Corrective & Maintenance Work (Continued) -

In a losing battle, the maintenance crews have attempted to keep up by shimming and trimming of doors and windows, relocating hardware, replacing broken window operators, repairing cracks, re-installation of trim and many other items.

- (2) Several years ago corrective work was attempted on Cabin "J-2" in the "C" area by complete removal of existing piers and replacement with new piers at proper depth, with a change in design. Unfortunately the work was limited and only seven of the piers were actually replaced. Thus the remainder of that structure was untouched and it is still the next to the worst cabin in "C" area. There is some satisfaction in knowing that our measurements showed subsequent movement in the new piers, relative to each other, was confined to approximately one inch.
- (3) Random attempts have been made throughout the cabin areas to readjust cabin levels by the expedient method of cutting pipe supports to allow downward movement. This practice alleviates the status quo, but of course does not affect additional future movement.

SECTION V

MOVEMENT IN CABIN STRUCTURES

E. PARTICIPATION OF NATIONAL PARK SERVICE

1. Criticism of the larger question, original site selection and site planning on the part of the NPS, offers little satisfaction at this time unless a view is taken of the consequences and resultant current problems. Accountability becomes a very real issue in the light of the type and quality of site improvement provided and that amount of improvement still to be accomplished.

The question of drainage becomes of paramount importance when it is realized that it is a prime contributing factor in frost upheaval and cabin damage.

We have searched the records for information that would define the responsibility for this particular question. The following references have been found (some are contextual):

- a. Notes from first conference in project architect's office in San Francisco dated Sept 3 to 6, 1955. Representing the NPS were the Assistant Superintendent, Chief of Development, Chief of WODC and others. Also a liaison representative for Public Roads and Park Service.
"...Dept. of Int., Parks Division are to provide the following utilities to the site and the distribution throughout the site for:
.....(d) Storm Drainage...."
- b. Contract between YP Co. and NPS dated Jan 1, 1956.
"Construction of facilities contingent upon NPS performing landscaping, installation of curbing and final surfacing of roads"
- c. Drawings prepared by WODC (entitled Canyon Area Development, dated 3-57, bearing No. NP-YEL 3442) show systems developed by their engineering branch for site improvement among which are underground drainage piping, culverts, catch basins, open drains, etc.

From the above, we would conclude that the responsibility for drainage rests with the NPS. It is further obvious to us that this responsibility remains to be discharged by accomplishment of corrective work and additional installation.

SECTION V

MOVEMENT IN CABIN STRUCTURES

F. CONCLUSIONS

1. Feasibility of corrective work on cabins.

As differentiated from repair or maintenance work, the following are items that would be required for corrective work:

- a. Removal and replacement of existing footings, or;
- b. Removal and replacement of existing backfill around present footings with non-frost-susceptible fill material.
- c. Possible reframing of substructure in some cases.

All these imply considerable expenditures of such size as to question their amounts in relation to the value of the structure itself. Notwithstanding is the lack of assurance that such work could be successful without correcting the drainage problem.

With the exception of reframing of porches, we must conclude that the above work is not feasible.

2. Correction of drainage.

Although we have previously stated that this subject is the domain of the NPS, the following items are listed for inclusion in a suggested program of corrective and additional work:

- a. Evaluation of present underground drainage pipe system. Replacement and additions as necessary.
- b. Study of present open ditches. Need for lining of ditches is anticipated.
- c. Complete storm drainage system including curbs and gutters, catch basins, etc.

3. Tolerable Limits of Cabin Movement.

We do not believe it is a matter of mere optimism to state that in all probability the proper disposition of the drainage will change the present untenable situation to one that will allow a reasonable maintenance program.

As previously discussed, cabin movement within the tolerable limits of two-tenths of a foot does not show deleterious effects in the structural frame and finish.

SECTION V

MOVEMENT IN CABIN STRUCTURES

G. RECOMMENDATIONS

Recommendations involving a third party (the NPS) would be of dubious value, but if stated here, they would take the same form as items listed under "Correction of Drainage" on the preceding page in which we have outlined a suggested program for the National Park Service.

More to the point is the following:

Propose a joint study by the NPS and the YP Co. of the drainage at Canyon Village. Such a study might start by jointly reviewing this section of the survey report. Review of other reference material may be in order. A trip to the site (particularly during the runoff of storm water) should prove enlightening to all. Further developments would be contingent and subject to conjecture at this point.

A study by counsel of the legal responsibility for the costs of repair, not only of the drainage system itself, but the repair of the damaged lodging units.

SECTION VII

GENERAL CONCLUSIONS

Sections IV, V and VI contain conclusions in detail and applicable to those sections in particular. In considering the report as a whole, weighing factors should be applied. YP Co. administration and management will assign orders of importance, based on experience, to the various deficiencies and problems surveyed. Orders of importance will also be weighed by practical matters of logical sequence and perhaps by cost.

Our judgement would place the three major considerations in the following order (for reasons as given):

- | | |
|--------------------------|--|
| First - Heating - | The cause of most guest complaints and a deficiency most easily sensed by him. |
| Second - Cabin Movement- | The guest is not so cognizant of this item and does not experience discomfort. Most would attribute the condition to poor workmanship. |
| Third - Acoustics - | This affects the guest too, but correction must wait <u>until cabin movement is arrested.</u> |

SECTION VIII

GENERAL RECOMMENDATIONS

Here again the major sections contain recommendations pertaining only to the section subject itself. Considerations must be made of the whole and weighing factors applied, as in General Conclusions.

Our overall recommendations would be as follows (in order of importance):

1. Firm up preliminary figures offered for the complete L.P. gas heating system installation and proceed with plans for programming the work.
2. Make immediate arrangements for preliminary discussions with the National Park Service concerning site drainage.
3. Budget funds for installation of walls and doors, for acoustical control.

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