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Project Summary

Evaluation of Color Infrared Aerial Surveys of Wastewater Soil Absorption Systems

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Color infrared (CIR) aerial surveys can identify soil absorption systems in which the effluent rises rather than percolates into the ground water. This report reviews the technique's scientific basis and effectiveness, and it discusses the procedures, equipment, and costs for such surveys.

This Project Summary was developed by EPA's Water Engineering Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Color infrared (CIR) aerial surveys have been purported to identify soil absorption systems that fail because effluent rises to the ground surface. To determine the value of CIR surveys, subject literature was reviewed, and interviews were conducted with seven firms that perform CIR surveys, thirty-two clients, and four experts in the field of aerial photography. The conclusions drawn from literature search and interviews cover five areas: usefulness of CIR surveys, theory, recommended best survey procedures, limitations, and costs.

Usefulness of CIR Surveys

A CIR aerial survey is a tool that can be used along with other survey techniques to locate failing soil absorption systems. A CIR survey can identify only those systems that fail because of rising effluent; it cannot identify systems that cause backups into homes, those with illegal bypasses to surface waters, or those that inadequately treat effluent before ground water discharge. As an initial screening method, however, a CIR survey is less expensive, more complete, and more accurate than other survey methods.

If an experienced interpreter reviews CIR photos, very few false positives are identified (a false positive is a system that is identified as failing but is actually working properly). The number of false negatives has not been well defined but appears to be low also (a false negative is a system that is not identified as failing but is later found to be failing). To ensure accurate results, the survey must use an interpreter specifically experienced with identifying failing soil absorption systems by means of CIR aerial photography.

CIR surveys must be confirmed with ground inspections of at least some suspected systems. The number of systems inspected depends on the area surveyed and the ultimate use of the survey results. As a rule of thumb, at least 10% of the suspected failures should be confirmed by a ground inspection.

An important side benefit of a CIR survey is the production of photos that document problems for local planners and officials in an uncontroversial way. CIR aerial surveys can also be done quickly and do not require the cooperation of the homeowners.

Theory

Aerial surveys employing CIR film are superior to those using conventional color, black and white, and thermal infrared films because certain character-

istic signatures of failing systems can be easily identified (for example, pools of surfaced effluent and patches of dead vegetation or lush growth).

The characteristic signatures of a failing system occur in stages and are caused by the surfacing effluent. At first, ponding effluent at the root zone of the cover vegetation provides extra nitrogen and moisture, which promotes lush growth. This subsurface fertilization and irrigation causes more healthy growth in a pattern mimicking the layout of distribution lines. However, extended root zone or surface saturation drowns the roots, and in a few weeks, the cover vegetation dies. Regrowth does not usually occur after the ponding subsides. The soil in the area must generally be amended or supplemented because of the deposition of nitrogen salts and acidic soil conditions, and it must be reseeded before new growth will occur. Often the soil absorption system is delineated by patches of dead vegetation surrounded by lush growth.

CIR film is effective in evaluating vegetative growth because CIR film is more sensitive than the naked eye or other films to vegetation density and lushness. This effectiveness is due to two factors. First, plants reflect two to nine times more near infrared radiation (700 to 900 nm) than visible radiation (400 to 700 nm). Second, healthy and luxuriant vegetation reflects proportionally more infrared radiation than stressed vegetation.

Pools of surfaced effluent can also be easily distinguished on CIR film because pools of water reflect almost no infrared radiation. Thus surfaced effluent appears black on CIR photos.

Recommended Best Procedures for CIR Aerial Surveys

A CIR aerial survey consists of five steps: survey preparation, image acquisition, photo interpretation, ground verification, and report writing.

Survey Preparation

Enough background information should be collected to plan the aerial survey and aid in photo interpretation and report writing. Information on soil types, treatment system designs, ground-water depths, topography, and land use is very valuable The amount of preparatory work required varies from survey to survey and depends on the area surveyed and the intended use of the survey results.

Flight lines must be laid out and the flight date scheduled. Several important factors must be considered when scheduling. All snow cover must be gone and the flight must take place during the growing season. Trees should not be in leaf because leaves will block the line of sight and hide many systems from the camera. Vacation homes must be photographed while the systems are being used Flights after a rainstorm will cause many false positives because puddles can be mistaken for surfaced effluent. Atmospheric haze will not affect CIR film, but foggy, very humid, overcast, or partly cloudy days will give photos with less contrast that will be harder to interpret. Flights should be flown as close to solar noon as possible for maximum penetration of sunlight and minimum interference from shadows. Finally, if flights can be flown when ground water is at its maximum height, soil absorption systems will be stressed, and the greatest number of surfacing failures can be found

Image Acquisition

The least expensive CIR aerial surveys can be done when standard aerial mapping equipment and procedures are used with CIR film. Standard procedures include the use of standard photogrammetric mapping cameras (23- x 23-cm, or 9- x 9-in. image area) and standard photographic procedures of 60% forward overlap of images for stereoscopic viewing and 30% image sidelap on each side to ensure coverage. Kodak Aerochrome 2443* is the only low-altitude CIR film available. A Wratten 12 filter should be used with this film to screen blue wavelengths.

Experience indicates that a 1:8000 scale is optimum for cost and image resolution.

Photo Interpretation

Standard aerial photo interpretation techniques are best. These involve viewing CIR transparencies on a light table with a pocket stereoscope that has 4-power magnification. As stated previously, accurate results require the use of an interpreter with specific experience in identifying failing soil absorption systems using CIR film.

Ground Verification

Ground verification is required for all CIR aerial surveys, but the amount of verification required depends on the use of the survey and the variations within the survey area.

If the exact number of failing systems must be known, then all failures identified during photo interpretation should be inspected. Fewer systems can be inspected if only general information is needed about the suitability of the survey area for soil absorption systems. In this case, only a representative number of the identified failures need be inspected, usually at least 10% of the total number identified.

The variation of the survey area will determine how many systems must be inspected if only a representative number are to be verified. For example, systems from each soil type, system type, and system age should be ground-verified.

Ground verification should always be done as close to the time of aerial photography as possible.

Report Writing

Reports are usually brief and include aerial photos identifying failing systems. The amount of background information such as soil types, system designs, and land use included in the report may vary depending on its intended use. The clients should make certain at the beginning of the survey that the final report will be packaged to suit their needs.

Limitations

A few limitations of CIR aerial surveys have been mentioned. A CIR survey can identify only one type of soil absorption system failure—that of effluent rising to the surface. Flight scheduling is restricted in ways that can be contradictory. For example, it may be hard to fly over an area of summer vacation homes when the systems are in use and there are no tree leaves to obstruct the view. In wooded areas, leaf cover can be a major problem.

In addition, several commonly found objects can give false positive identifications. Large rock formations, puddles, and gardens can mimic failing systems, but an experienced interpreter can usually distinguish these. Properly operating shallow soil absorption systems and evapotranspiration systems may show lush growth and be interpreted as failing. Large shadows can obscure systems or be interpreted as surfaced effluents.

Costs

Past survey costs have been quite variable, ranging from $0.79 to $10.34 per house. Costs depend greatly on the specific survey, but general comments

*Mention of trade names or commercial products does not constitute endorsement or recommendation for use

can be made. Survey preparation, photo interpretation, ground verification, and report writing are primarily labor intensive and depend on labor costs. These labor costs in turn depend on the survey area size, the number of suspected failures, and the intended use of the survey results. Image acquisition costs depend on the survey area size and the variable costs of CIR film, film processing, and airplane rental (including fuel costs).

Conclusions

- CIR aerial surveys are valuable tools for locating soil absorption systems that are failing because effluent is rising to the surface. However, CIR aerial surveys cannot locate failures resulting from backups into homes, illegal bypasses, or inadequate treatment by the soil system.
- CIR aerial surveys have several advantages over other survey methods in that they are quick, non-labor-intensive, relatively inexpensive, comprehensive, and possible without homeowner cooperation.
- Failing systems leave characteristic signatures on the surface because of increased moisture at the root zone. In the early stages, lush growth is promoted; but in later stages, plants are drowned and do not regrow.
- CIR film is more effective than the naked eye or other types of film in locating signatures of surfacing effluent because the film is more sensitive to changes in the condition of vegetation. The use of color film in addition to CIR film is an unnecessary added expense.
- Standard photogrammetric mapping equipment and procedures give the best results at the lowest cost. A 1:8000 scale appears optimal in terms of cost and image resolution.
- Interpretation of CIR aerial photos must be done by interpreters familiar with CIR film, soil absorption system design, and the characteristic signatures of a failing system
- Several objects can mimic failing systems: large rock formations, puddles, gardens, shallow trench systems, and evapotranspiration systems.
- If experienced interpreters are used, very few mistakes are made in identifying failing systems. However, inexperienced interpreters may miss failing systems (false negatives) or mistake properly operating systems for failing systems (false positives). The latter is less critical.
- Ground verification of suspected failures is an essential part of CIR aerial surveys to ensure accurate interpretation of photos. Ground verification should occur as soon after the aerial survey as possible.
- CIR aerial survey costs are quite variable, with past surveys costing from $0.79 to $10.34 per house.

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The complete report, entitled "Evaluation of Color Infrared Aerial Surveys of Wastewater Soil Absorption Systems," (Order No. PB 85-189 074/AS; Cost: $11.50, subject to change) will be available only from:
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