ELARC: HYDROLOGIC FORECASTING FOR FLOODPLAIN MANAGEMENT WITHIN THE POTOMAC RIVER BASIN - PHASE I

William B. Reed, Stuart S. Schwartz, and Richard S. Hammerschlag

Technical Report NPS/NRWRD/NRTR-90/04

WATER RESOURCES DIVISION

National Park Service • Department of Interior
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ABSTRACT

The Enhanced Limited Automatic Remote Collection (ELARC) system is a microcomputer-based hydrologic forecasting system that uses real-time streamflow data retrieved by telephone line from upstream data loggers. The ELARC system generates a computer screen displayed report, including a hydrograph for the target gage. The system was developed for the Chesapeake and Ohio Canal National Historical Park by the Interstate Commission on the Potomac River Basin in conjunction with the National Weather Service and the National Park Service. The system is being implemented by the National Park Service in two phases. Phase 1 forecasts flows which can result in drownings in the vicinity of the Great Falls of the Potomac. Since the majority of these deaths occur when the Potomac River stage is below bankfull, the system was designed to forecasts subtle changes in the corresponding flows. Phase 2 will require system refinements to forecasts flood flows that necessitate management actions to protect park structures.

INTRODUCTION

The National Park Service's Water Resources Division (WRD) has been working closely with Chesapeake and Ohio Canal National Historical Park (CHOH), and National Capital Region's Center for Urban Ecology (CUE) on the design, implementation, and coordination of a five year (funded FY 85 to 89) floodplain management study. Approximately 85% of the park is within the 50-year floodplain of the Potomac River. The canal is 184 miles long, extending from Washington, D.C. to Cumberland, MD. There are 11 aqueducts, 75 canal locks, 6 inlet locks, and 1 tidal lock. Of the original lock tender houses, only a few have not suffered severe flood damage and many are missing entirely. Only a few sections of the canal are currently watered. In these sections only a few of the canal locks are functional.

Because the C & O Canal is mainly located within the floodplain of the Potomac River, the potential for flood-caused property damage and loss of irreplaceable cultural resources is high. Floods also threaten visitor and employee health and safety. However, flood flows are not the only dangerous conditions. Therefore, the major purpose of the five-year study was to provide the park with a scientific approach, technology, and data base for floodplain (rather than flood) management, and focused on two important management concerns:

> Phase 1 - "low flow" recreational hazards adjacent to a two-mile reach of the Potomac River immediately downstream of the Great Falls of the Potomac; and
>
> Phase 2 - high flow (flood) hazards adjacent to a 184-mile reach of the Potomac River from Washington, D.C. to Cumberland, MD.

Both structural and non-structural measures were developed to support effective resource, visitor, and land use management. This paper describes Phase 1. The objective of the Phase 1 was to develop a warning system for recreational hazards. Because of this specific objective, in a recent survey of 18 warning systems, the system developed for CHOH was described as "perhaps the most unique" (Gruntfest, 1988).

PHASE 1 - RECREATIONAL HAZARDOUS FLOWS NEAR GREAT FALLS

To reduce the occurrence of accidental drowning in the vicinity of Great Falls, the National Park Service (NPS) established a computer-based real-time warning system that alerts park management and river safety personnel to imminent hazardous conditions. These conditions occur throughout the year, but are most dangerous during the spring and summer when visitors to CHOH venture into the waters of the Potomac River or out onto the islands of the Potomac River Gorge. From 1975 to 1985, an average of seven people a year drowned in the area. The majority of accidental drownings occurred when the stage of the Potomac River was between 3.5 and 5.0 feet at Little Falls. (Little Falls is approximately 9 miles downstream of Great Falls.) These stages are below bankfull and therefore, the situation is a "low flow" rather than a flood flow concern. The drownings seemed to result from circumstances related to relatively small but rapid changes in river stage. These conditions can also result in a visitor becoming trapped on an island when a previously safe side channel becomes hazardous due to velocity and depth increases associated with increased river stage, e.g., the "stepping stones" used to traverse side channels become submerged.

As originally planned, phase 1 had two goals:

> Goal 1 - develop the technology for a warning system that predicts for Little Falls (site of existing telemetered gage and historical record), the below-bankfull flows associated with park management concerns within the Potomac River Gorge near Great Falls; and
>
> Goal 2 - modify the warning system developed for Little Falls, so a gage installed at Great Falls is the target gage.

To accomplished these goals would require completion of the following tasks:

> (1) select communication (data transmission) technique for system (goal 1);
>
> (2) select gaging station sites and design monitoring network for system (goal 1);
>
> (3) develop computer software for system (goal 1);
>
> (4) establish monitoring network by upgrading existing stations so they are compatible with the system and establish new stations where required (goals 1 and 2);
>
> (5) establish the relationship between observed hazardous conditions within the Potomac River Gorge to Potomac River stage upstream at Great Falls (goal 2); and
>
> (6) evaluate the sensitivity of a telemetered gaging station at Great Falls to determine if the site can be used as a surrogate for stations within the gorge (goal 2).

Goal 1

The first goal was accomplished during the five-year study time frame. The real-time warning system developed is known as the Enhanced Limited Automatic Remote Collection (ELARC) system. The system uses hardware (data loggers) prepared for the National Weather Service (NWS) (Titus, 1985). These data loggers were installed at US Geological Survey (USGS), US Army Corps of Engineers (COE), and NPS-established gaging stations. The software for the system was prepared by the Interstate Commission on the Potomac River Basin (ICPRB) specifically for the NPS. The system can be networked so users at remote computer locations can also receive forecasts. The system technology also has the potential for being expanded to predict high flows (floods) and provide timely information to all parks adjacent to the Potomac River as well as the National Capital Regional Office.

The initial (goal 1) warning system uses a gaging station network of five stations; two on the Potomac River, Point of Rocks (most upstream gage) and Little Falls (target gage); and one station each on the following three (between Point of Rocks and Great Falls) major tributaries: Monocacy River, Goose and Seneca Creeks (Figure 1).

The initial system uses simple time-of-travel hydrologic routing for the relatively low flow conditions for which it was designed; however, a more complex routing technique may be necessary when the system is revised to include flood flows (Phase 2). The configuration of the low flow system is:

(1) one host computer currently located at CUE (the host computer calls the network gaging stations and performs all calculations); and

(2) one remote computer presently located at CHOH Palisades District Office near Great Falls Tavern (the remote computer receives the predictions from the host computer).

Unlike other systems (e.g., ALERT, IFLOWS), the primary design criteria for ELARC was to develop a system that required "no action" for operation on the part of the user, i.e, we wanted to avoid "user unfriendly computers" that were noted by Kachic (1988) as one of the problems that surfaced during the early implementation of the Integrated Flood Observing and Warning System (IFLOWS). Therefore, the system was designed so a user has only to read the screen (Figure 2) to obtain the current prediction; i.e., once "running" the system requires no further action by the user to continue operating. Additionally, the system was designed so it can easily be modified by someone familiar with PC DOS for different situations (such as the addition of the Great Falls station, goal 2).

While developing the system we were able to find a solution to another potential problem, long-term maintenance. By interagency agreement, the NWS will provide repairs and emergency maintenance to all gaging stations utilized by the low flow system; in return, the NPS has upgraded the NWS telemetry equipment at nine gaging stations within the Potomac River Basin. This has enhanced the NWS river forecasting capabilities including the NWS flood warnings provided to the park. This mutually beneficial situation occurred because we selected to use telephone lines for data transmissions, and subsequently selected hardware prepared for the NWS.

Additionally, the two User's Manuals for the system--one for ELARC which is required for the host station (the station that calls the network gaging stations and performs all calculations) and one for the "Receive Program" which is the software required for remote computer stations--are both relatively thin. However, as one might expect, the Programmer's Manual for the system is unavoidably thick, and unfortunately, unavoidably "user unfriendly."

Although we were able to avoid some technical problems; as discussed by Johnson (1988) to be effective the system not only has to be technically sound, but must be integrated into the administrative structure for decision making. For land management agencies with high turnover among administrative personnel, this may prove to be the greater challenge.

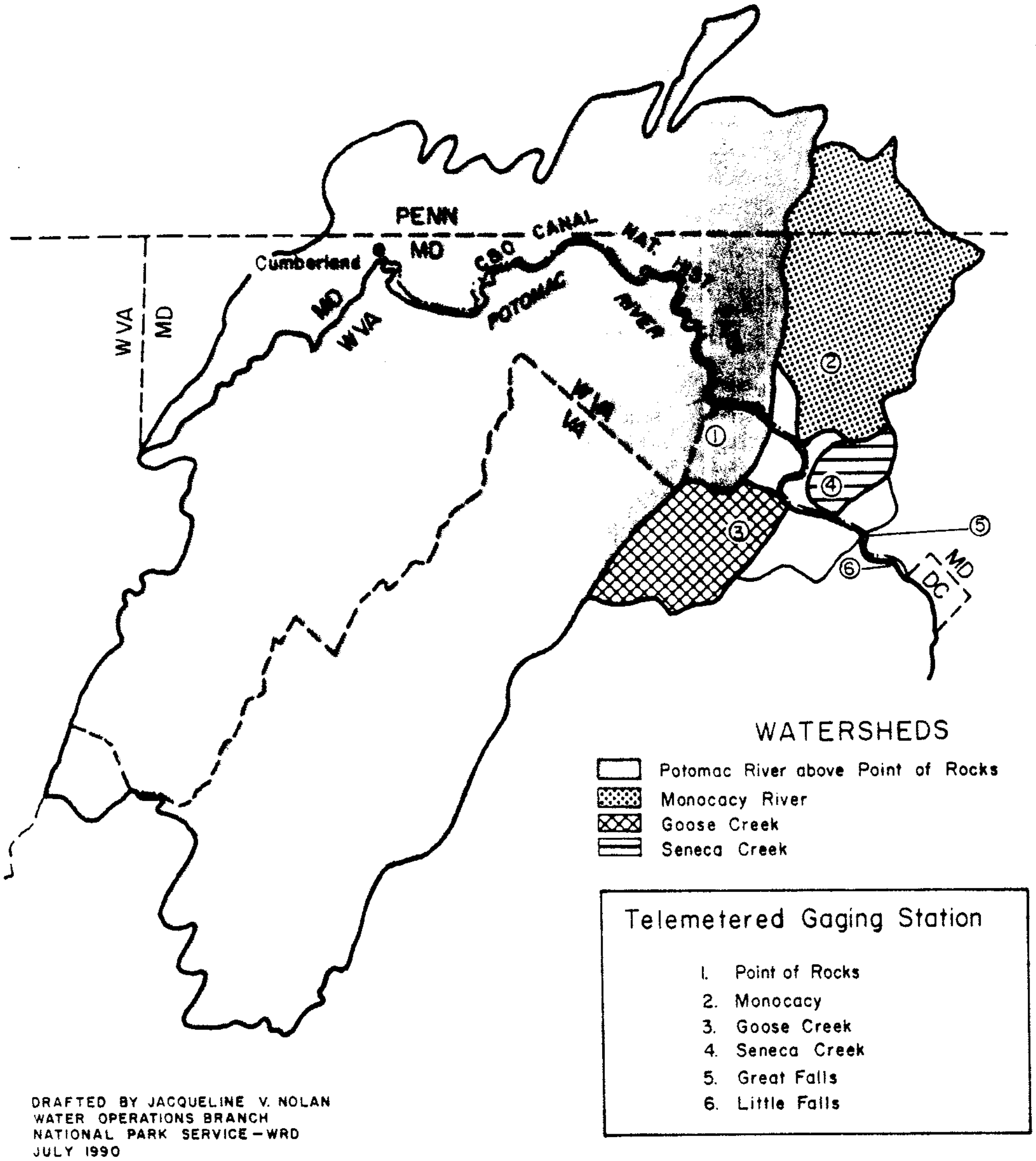
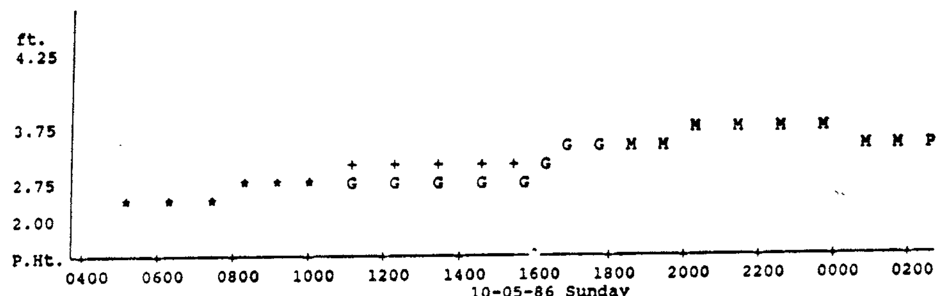


Figure 1. Gaging Station Network for Great Falls

Goal 2

The second goal was not accomplished during the five-year time frame because of several logistical (non-technical) problems. However, a temporary network of staff gages was designed by WRD (Figure 3) and established by CHOH. Staff gages were installed at several locations within the Potomac River Gorge below Great Falls. Staff gage readings, along with current stage height at the Little Falls gage, were recorded by park staff. The observed relationships between these gages is presented in Figure 4. As shown, the sites within the gorge respond differently to changes in stream flow over the range of flows considered important for this study phase. These differences are attributed to the abrupt changes in channel geometry and the braided nature of the channel within the gorge. Indeed, as in many units of the National Park System, it is the features that attract visitors to the area, that cause the area to be potentially hazardous to those who are uninformed or ill prepared.

By interagency agreement (prepared by CHOH) the COE has provided permission to use their facility, the Washington Aqueduct Intake Structure, as the site for the Great Falls gaging station. However, although the station has been designed by WRD, it has yet to be constructed. After establishing the gage, gage data will be needed to determine if the station is sensitive at relatively low flows, i.e., will small changes in flow cause a measurable change in the stages being recorded.



Little Falls Report 10-05-86 16:00:00

-Time-	-P.H.T.-	-Disch.-	-Stage-	-Stations-	-Status-
1600	3.00 ft	3837.0	1.75	+ 11 Pt of Rocks	OK
1800	3.01 ft	124.6	1.33	8 Monocacy	OK
2000	3.02 ft	40.8	1.29	11 Goose Cr.	OK
2200	3.04 ft	4280.4	3.08	+2 L Falls	OK
0000	3.06 ft				
0200	3.12 ft				

WAITING 14:22:43

Figure 2. Example of a Typical Screen Display

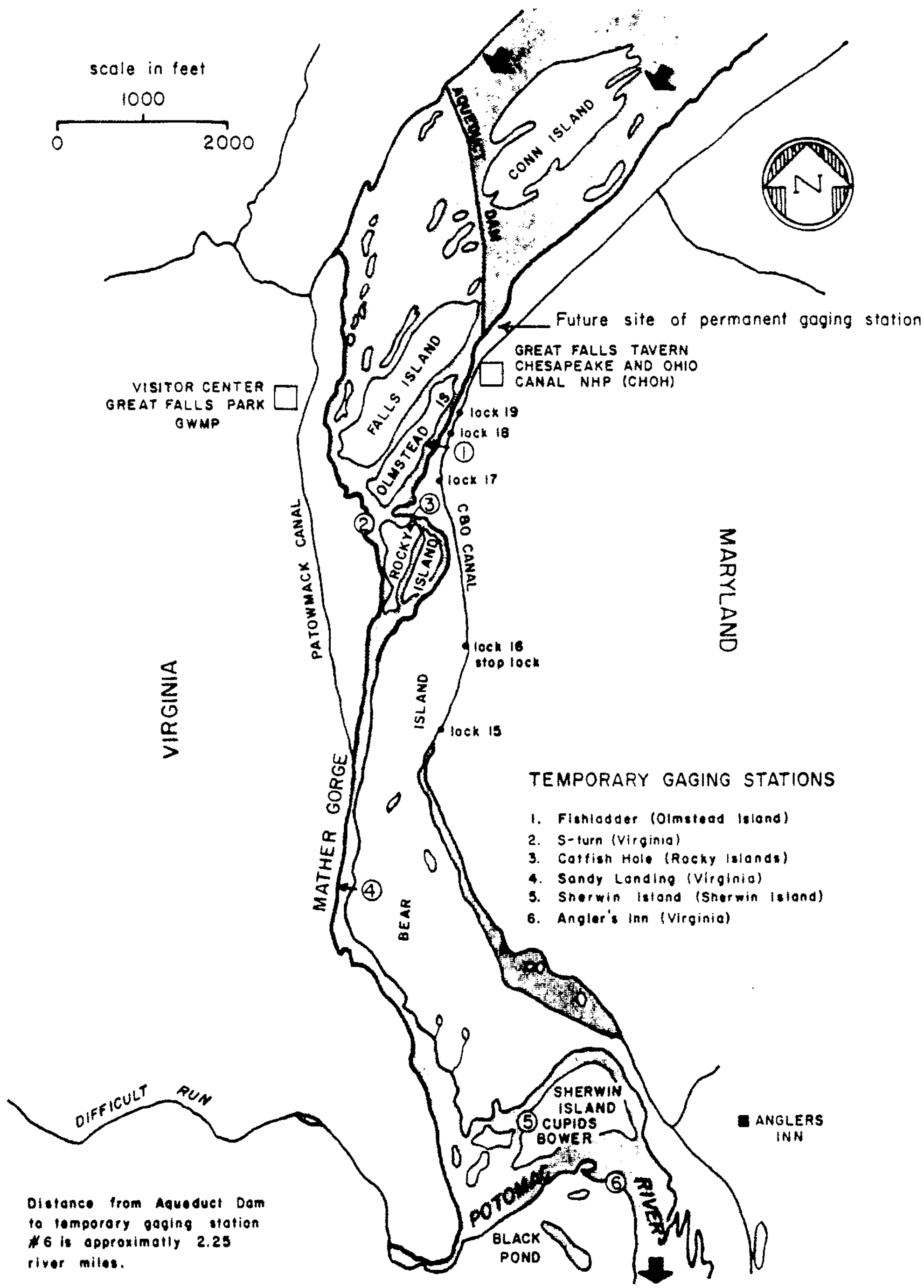


Figure 3. Temporary Gaging Stations Below Great Falls

Whereas a temporary network of staff gages was established, additional data are required if a gage installed at Great Falls is to be used as the target gage (as a surrogate for monitoring conditions within the gorge). Specifically, additional data for the temporary network of staff gages are required to document when hazardous conditions occur at visitor use areas within the Potomac River Gorge. These data need to be collected, after establishing the Great Falls telemetered gaging station to provide concurrent data for the telemetered station and temporary stations. The concurrent data will then be used to establish the relationships between observed hazardous conditions within the gorge and Potomac River stages upstream. Currently these relationships exist only for Potomac River stages downstream (Figure 4), i.e., the current system routes flows from above Great Falls (Potomac River at Point of Rocks, Monocacy River, Goose Creek, and Seneca Creek; shown on Figure 1) to Little Falls below the gorge.

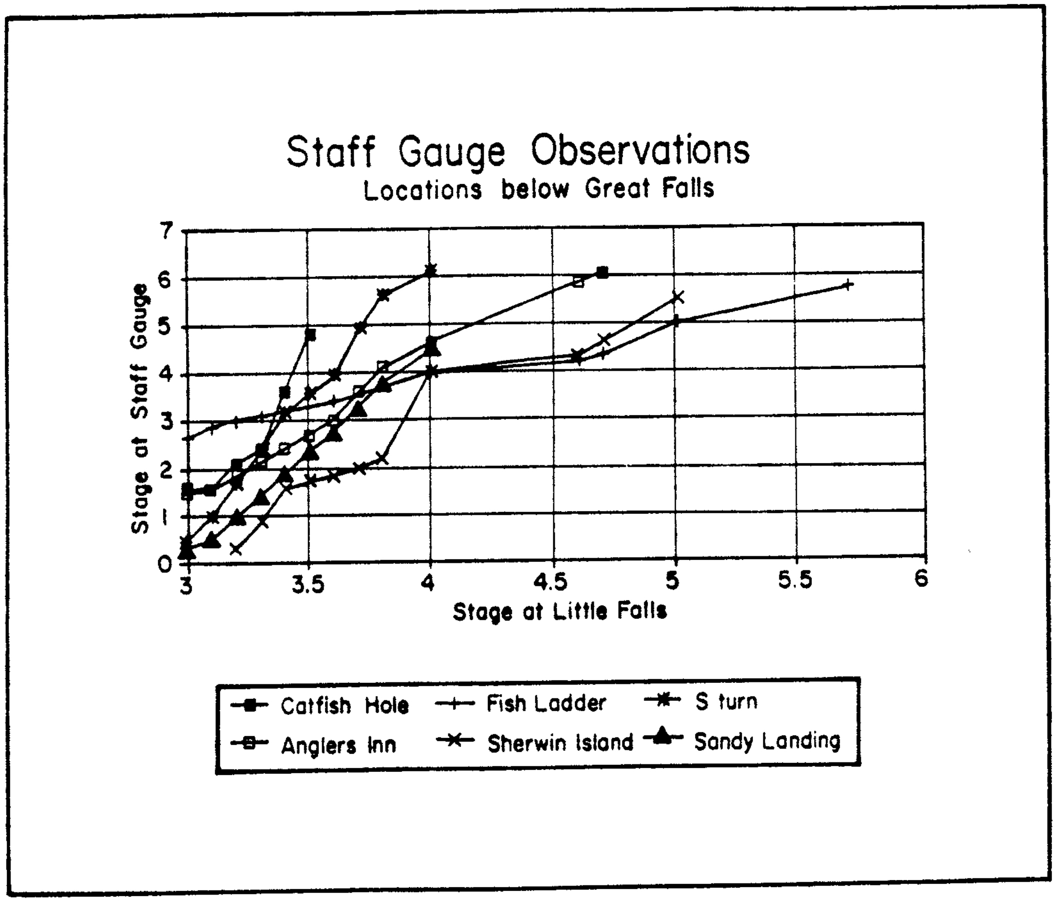


Figure 4. Gaging Station Relationships

If an analysis of the data proves the Great Falls telemetered gage is adequate for the purposes of this phase, the system should be modified so predictions are made for Great Falls instead of Little Falls. It is hoped that this system refinement will improve the correlation between predicted stage and hazardous conditions within the Potomac River Gorge, and eliminate the uncertainty (inherent to the initial warning system) as to when hazardous conditions could occur.

To achieve this refinement (to achieve goal 2 of phase 1), the following four tasks need to be completed:

(1) establish the telemetered gaging station at Great Falls, and begin to record data by ELARC or by independent data logger (LARC);

(2) after telemetered gaging station has been installed, collect temporary gaging station network data during the range of flows of concern for this phase to develop an empirical relationship between Great Falls stage and hazardous conditions downstream within the gorge;

(3) evaluate recorded Great Falls data to determine if the station is sensitive enough at the relatively low flows of concern to allow the site to be effectively used as the target gage for the low flow recreational hazards warning system; and

(4) upon completion of the above tasks and if the gage is adequate, modify the initial system so Great Falls is the target gage.

However, before committing additional resources, it may be prudent to first determine how the improved system would be integrated into the administrative structure for decision making. Recent changes in park administrative and operational staff may provide an additional justification for evaluating the overall program.

SUMMARY

To reduce the occurrence of accidental drowning in the vicinity of Great Falls of the Potomac River, the National Park Service established a computer-based real-time warning system that alerts park management and river safety personnel to imminent hazardous conditions. However before committing additional resources to provide system refinements, it may be prudent to first determine how the system will be integrated into the administrative structure for decision making. For land management agencies with high turnover among administrative personnel, this may prove to be a greater challenge than the technical design of the warning system.

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The National Park Service Water Resources Division is responsible for providing water resources management policy and guidelines, planning, technical assistance, applied research, training and operational support to units of the National Park Service. Program areas include water rights, water resources planning, regulatory guidance and review, hydrology, water quality, watershed management, watershed studies and aquatic ecology.

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